D2.4 Analysis report on available and emerging communications technologies

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Review

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1. References/Publications/other sources

Most of the information contained in that document is extract from IALA, IMO or ITU documents.

GMDSS Master Plan, GMDSS.1/Circ. 17, 2015

IMO e-navigation strategic implementation plan (SIP) (NCSR1/27/Annex 7)

IALA Maritime Radio Navigation plan

IALA Maritime Radio Communications Plan (MRCP), edition 2 October 2012

Resolution A.1001(25), CRITERIA FOR THE PROVISION OF MOBILE SATELLITE COMMUNICATION SYSTEMS IN THE GLOBAL MARITIME DISTRESS AND SAFETY SYSTEM (GMDSS) (Adopted on 29 November 2007)

RESPONSE TO MATTERS RELATED TO ITU WORLD RADIOCOMMUNICATION CONFERENCE (1.1.2.2) Report of the eleventh meeting of the Joint IMO/ITU Experts Group on Maritime Radiocommunication matters Including information on Completion of the detailed review of the Global Maritime Distress and Safety System (GMDSS) (5.2.5.2) (agenda item 14), and Response to matters related to the Radiocommunication ITU R Study Group (1.1.2.2) (agenda item 16), NCSR 3/17, 26 October 2015

Characteristics of a digital system, named Navigational Data for broadcasting maritime safety and security related information from shore-to-ship in the 500 kHz band Characteristics of a digital system, named Navigational Data for broadcasting maritime safety and security (NAVDAT) , Recommendation ITU-R M.2010, March 2012.

Characteristics of HF radio equipment for the exchange of digital data and electronic mail in the maritime mobile service, Recommendation ITU-R M.1798-1 (04/2010)

EfficienSea 2 project deliverables

VDES documents:

- VDES, Appendix 18 (REV WRC-15)
- RESOLUTION 360 (REV.WRC 15) Consideration of regulatory provisions and spectrum allocations to the maritime mobile-satellite service to enable the satellite component of the VHF Data Exchange System and enhanced maritime radiocommunication

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2. Scope of the document

This document is a deliverable of WP2 task 2.2 which aim is the evaluation of communication technologies in the context of the EfficienSea 2 project. The work package 2 concerns the novel communication technologies for e-maritime and e-navigation services which are considered as a major challenge. Quality of services requirements for the maritime communication system are more and more demanding in terms of availability, robustness, integration onboard ships and in terms of comfort of use for the mariners. The GMDSS (Global Maritime Distress and Safety System) is under a modernization process in order to fill some gaps such as polar communications. The Arctic communications is the typical use case that cumulates most of the technical or environmental issues like RF signal vulnerability, worst navigation conditions, few coastal infrastructures... With the opening of maritime summer routes it is a high priority to consider such issue. A status of the present communication technologies will be presented. In addition, the emerging technologies like VDES, Iridium Next, Inmarsat GlobalXpress, NAVDAT and the Galileo return link or other relevant systems will be considered. Their main characteristics relevant to M2M communications or information service provision will be presented.

An evaluation of the available and emerging communications systems will be done in the scope of the EfficienSea 2 project. On the evaluation process, some use cases of communication links will be considered. The associated requirements will be established and compared to the existing and novel communication systems. The present gaps will also be discussed and how they may be filled with emerging technologies. The interfaces with other tasks of the project will also be taken into account. The interfaces concern especially the WP2 task 2.1 (VDES - VHF Data Exchange System) and the WP3 task 3.2 (Services specifications). The main characteristics of the VDES will be presented and how they may match with the desired characteristics for service provision.

Note that two specific deliverables of WP2 task 2 will be dedicated to space weather space weather impacts on RF communication signal:

- D2.5 Report on space weather effects on communication and positioning services)
- D2.6 Report on space weather forecast warning service for polar Telecommunications and Positioning/Navigation.

3. E-Navigation definition and IALA activities

e-Navigation is an IMO-led broad strategic vision for the harmonization of marine navigation systems and supporting shore services, underpinned by user needs. The definition adopted by IMO is: “The harmonized collection, integration, exchange, presentation and analysis of marine information onboard and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment.”

IALA, a leader in e-Navigation (International Association of Marine Aids to Navigation and Lighthouse Authorities) is in charge of harmonizing aids to navigation worldwide and to ensure that the movements of vessels are safe, expeditious, cost effective and harmless to the environment.

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The e-navigation concept intends to integrate and to harmonize the maritime communication systems.

4. Present maritime context

4.1 Maritime services

The Maritime Service Portfolios represents a set of services grouped according different function or/and geographical region. These can be operational services or technical services. A comprehensive description of the following MSPs can be found in e-NAV12/81 Annex 4. A list of MSP is given hereafter:

- VTS Information Service (INS);
- Navigation Assistance Service (NAS);
- Traffic Organization Service (TOS);
- Local Port Service (LPS);
- Maritime Safety Information (MSI) service;
- pilotage service;
- tugs service;
- vessel shore reporting;
- remote monitoring of ships systems;
- Telemedical Assistance Service (TMAS);
- Maritime Assistance Service (MAS);
- nautical chart Service;
- nautical publications service;
- ice navigation service;
- real-time hydrographic and environmental information services;
- Search and Rescue (SAR) Service.

MSP areas are divided into the following:

- harbour operations;
- operations in coastal and confined or restricted waters;
- transocean voyages;
- offshore operations;
- operations in Arctic, Antarctic and remote areas.

The implementation and development of MSP is under IMO governance via the IMO Strategy Implementation Plan (SIP). Services would be proposed to be arranged on two registries:

• generic registry contains specifications of particular functional services, which might be implemented by particular organizations in different areas

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• service registry contains list of services practically implemented by different providers in different areas and operating according to the specification contained in the generic registry;

4.2 Maritime communication applications

Maritime communication applications are hereafter sorted in three categories:

Safety applications: related to the safety of life at sea, you can find here the applications in case of a distress alert but also the way to avoid them such as AtoN or collision avoidance applications;

Operational applications: weather, chart, ECDIS, ports operations;

Commercial: voyage planning, crew and passengers communications.

Examples are listed in the following table.

Safety	Operational	Commercial
▪ AIS position reports ▪ AIS AtoN ▪ Digital Selective Calling ▪ Long Range Identification and Tracking ▪ Differential GNSS ▪ NAVTEX/SafetyNET ▪ VTS coordination ▪ SAR ▪ Distress and Urgency alerting/calling	▪ Weather data ▪ Ship reporting ▪ Notifications to coastal States ▪ Port arrival notification ▪ Maritime Information Overlays ▪ Port & VTS surveillance feeds ▪ Electronic chart updates ▪ Access to vessel & equipment manuals ▪ Remote maintenance & service ▪ Telemedicine	▪ Voyage orders ▪ Commercial port services ▪ Operational reports ▪ Cargo telemetry ▪ Point of Sale ▪ Crew personal communications ▪ Passenger Internet access ▪ Crew training Infotainment

Table 1 - Overview of maritime communication applications by type (IALA source)

4.3 GMDSS and its modernization plan

The Global Maritime Distress and Safety System (GMDSS) is an international system that uses terrestrial and satellite technology and ship-board radio systems. The system is intended to perform the following functions: alerting (including position determination of the unit in distress), search and rescue coordination, locating, maritime safety information broadcasts, general communications, and bridge-to-bridge communications. The GMDSS is described in the Safety of Life at Sea (SOLAS) Chapter IV convention. Seventh functional requirement are identified. "Every ship, while at sea, shall be capable of transmitting and receiving maritime safety information". In case of a distress alert, search and rescue authorities ashore (MRCC: Maritime Rescue Coordination Center), as well

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as shipping in the immediate vicinity will be rapidly alerted through satellite and terrestrial communication techniques so that they can assist in a co-ordinated search and rescue operation. This system, which the world's maritime nations have implemented GMDSS, has changed international distress communications from being primarily ship-to-ship based to ship-to-shore (RCC) based. Under the GMDSS, all cargo ships of 300 gross and upwards or passenger ships must be equipped with radio equipment that conforms to international standards (SOLAS convention, chapter IV, 1999).

The GMDSS also requires ships to receive broadcasts of maritime safety information which could prevent a distress from happening. Thus, with GMDSS all ships are able to receive and transmit information in case of a distress alert. Four areas are identified (Table 2).

Area number	Area description
Area 1	An area covered by a coast station using VHF DSC, typical 30 nautical miles (56 km) to 40 nautical miles (74 km) from the Coast Station.
Area 2	An area covered by a coast station using MF DSC typical 180 nautical miles (330 km) offshore during daylight hours Around 400 nautical miles (740 km) offshore during night time.
Area 3	An area outside areas A1 and A2, covered by the Inmarsat GMDSS service, which is between about latitude 76 Degree North and South, but excludes A1 and/or A2 designated areas.
Area 4	An area outside Sea Areas A1, A2 and A3. This is essentially **the polar regions**, north and south of about 76 degrees of latitude, excluding any A1 or A2 areas.

Table 2 - Overview of the 4 area defined by the GMDSS (see also communication particularities on Table 6).

The communication systems that presently compose the GMDSS are listed and detailed in the next chapters. The GMDSS is in place since many years with technologies that are not up to date. Several gaps have been identified by IALA working groups experts. Some of them concern the data management like a lack of mechanisms to provide SAR (RCC) function with the full range of relevant e-navigation information in digital format, the insufficient access to and quality of information from ships in distress and the integrity checking. In terms of system and equipment, collecting information pertaining to a distress situation consumes valuable time.

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There is major challenge in area A4 where no satellite communication service exists. The MF/HF remains the only option but it should be noted that the required shore based infrastructures are constantly being reduced.

The voice communication and the data transfer also require to improve communications means. A strong issue is the lack of an effective SAR system in some parts of the world especially the polar areas. The Inmarsat system as a mobile satellite service is presently the only that participates to long range communication. However, the system is based on geostationary satellites that are not operating at latitudes higher than 65°.

The Joint IMO/ITU Experts Group on Maritime Radiocommunication Matters that instruct the revision of SOLAS chapter IV has decided to work towards an entry-into-force at a date of 2020. One important evolution that is envisaged is to consider additional satellite systems in the GMDSS. Specific requirements have been drawn for the GMDSS evolution. More details will be given in the paragraph 5 on the present status of that modernization and in particular the accreditation for Iridium in addition to Inmarsat as a new mobile satellite service.

4.4 Maritime areas

As shown in the following plot based on one day of worldwide AIS data, the maritime navigation concerns all areas above 60° South.

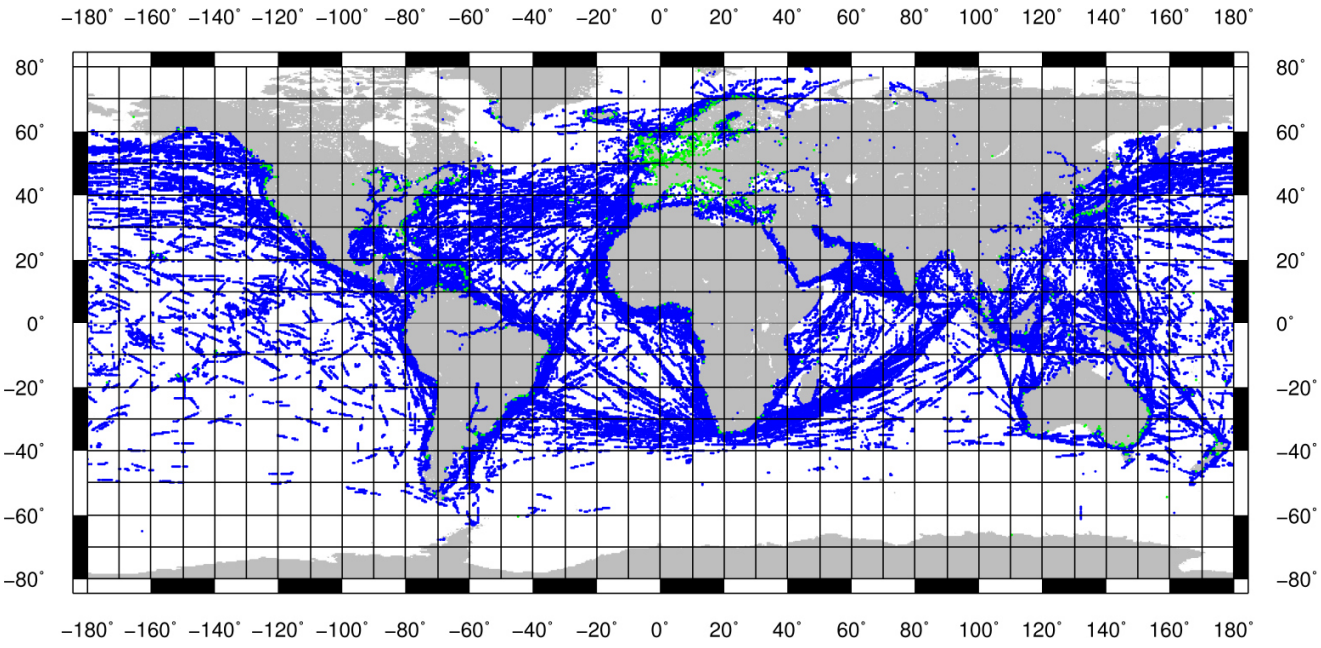

Figure 1. One day of worldwide AIS data - not exhaustive sources (blue : Satellite, green : terrestrial data)

Some areas are known as of very high density like the ports of Rotterdam or Shangai, like the Straits of Malacca or the Mediterranean and Baltic Seas (Figure 2)

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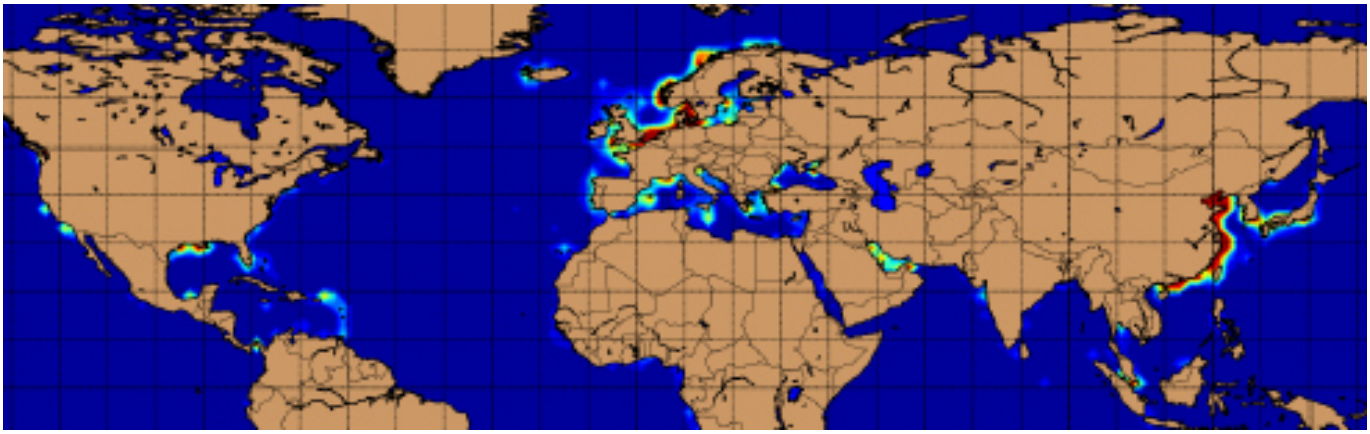

Figure 2. High ship density areas (in red), AIS data (CLS source)

However, the ship navigation may present significant seasonal variations especially for fishing activities or for the Northern polar navigation.

When considering all the possible ship trips, some areas of navigation may be defined. They mainly consider the proximity to a port, the proximity of the coast, the high seas and the polar areas. The area covered by each area may be debated. One possible criteria is the range associated to the communication systems (like the cellular technologies, the VHF transmission…). That point will be analyzed in the next chapters of the document.

The following decomposition of maritime areas is proposed in Table 2 in the context of the EfficienSea2 Project.

Maritime areas	Definition	Coverage
1	Inside port	< 0.3 nm
2	Approaching port area	≈ 1 nm
3	Coastal navigation	1 to 5 nm 5 to 25 nm
4	Coastal approach	Up to 100 nm
5	High seas	> 100 nm
6	Polar areas	Up to several thousands of km

Table 3. e-Navigation area definition (EfficienSea2 context)

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5. Existing communication system technologies

There a large variety of communication technologies that may be used on board a ship. It should be noted that not only pure maritime communication technologies will be used for EfficienSea 2 but also hybrid communication system by mixing with cellular or wireless communication technologies. The range of applications may be at a global, regional or local scales. The communication systems in use may be different when considering shipping, fishing or off-shore activities. The cost including both the terminal and the communication service may be a significant parameter for a system choice especially for small vessels. Maritime regulations especially for SAR also impact the on-board communication equipments.

The present chapter is divided into for sub-chapters. The first is a summary of the main maritime communication systems in used. It strongly relies on the IALA maritime radio communications plan. This plan provides a status of the radio communication in the maritime mobile band. The second sub-chapter is a summary of the communication systems that are presently compliant with the GMDSS. The third sub-chapter is dedicated to a more detailed analysis of the existing satellite communications with a focus on a SWOT comparison approach. On the same way, the last sub-chapter provides a SWOT analysis of the terrestrial communication systems and hybrid systems for high data rates.

The Maritime Radio Communications Plan (MRCP) has been developed by IALA to assist in the selection of radio communication systems required to support e-Navigation. The current status of radio communication in the maritime mobile bands is discussed and forms the basis of projections for future developments needed to support e-Navigation.

5.1 Main communication systems on board ships (by frequency band)

The main systems are shortly presented hereafter. The characteristics are then summarized on Table 1.

MF/HF

Digital Selective Calling (DSC) (MF/HF & VHF bands)

DSC is a technique using digital codes which enables a radio station to establish contact with, and transfer information to, another station or group of stations, for distress or general communications over medium to long range distances. DSC is primarily used for distress alerting, urgency and safety calling within ship-to-ship, ship-to-shore and shore-to-ship prior to initiating distress, urgency and safety communications using radiotelephone or MF/HF radiotelex. DSC distress alerts, which consist of a preformatted distress message, are used to initiate emergency communications with ships and rescue co-ordination centres. DSC is an

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element of the Global Maritime Distress and Safety System (GMDSS). DSC can also be used to call individual stations, groups of stations, or all stations in radio range..

The ITU has allocated a DSC distress and safety channel in the MF, each of the HF and the VHF marine radio bands. These are:

- MF/HF DSC : 2187.5 4207.5 6312.0 8414.5 12577.0 16804.5 (kHz)
- VHF DSC : VHF marine channel 70 (156.525 MHz).

Voice communication

Various uses are made of the MF/HF radio spectrum by the maritime community for communication of voice in ship-ship, shore-ship and ship-shore modes of operation. General voice communication takes place across the band 1.6-26.5 MHz Channel bandwidths are typically 3 kHz. Digital communication within the MF/HF bands is a relatively new technology with high potential.

Data Communication

Current and emerging HF digital modulation schemes provide new opportunities utilizing data transmission in this frequency band (1.6-26.5 MHz, Recommendation ITU-R M.1798, 2010). The systems are IP level-compatible making interoperability possible.

Narrowband Direct Printing (NBDP or radio telex).

NBDP is a technique which automates radio signals to telegraphy. NBDP is FSK modulated onto HF channels of 0.5 kHz and supports low speed data transmissions (100 bps) in the maritime mobile service bands within 1.6-26.5 MHz. NBDP is an element of GMDSS and can be used as the text based distress follow-up communications and general communications between ship-to-ship, ship-to-shore and shore-to-ship especially to overcome the language difficulties. The use of NBDP for general communication is declining and is now used for position reporting from ships and promulgation of meteorological warnings and forecasts from coast stations.

Navigational Telex (NAVTEX)

NAVTEX is an international, automated system for instantly distributing Maritime Safety Information (MSI) such as maritime navigational warnings, weather forecasts and warnings, search and rescue notices and similar information to ships. A small, low-cost and self-contained smart printing radio receiver (NAVTEX receiver) is an element of GMDSS and installed on the ship's bridge. Messages are broadcasted in English on 518 kHz, while 490 kHz and 4209.5 kHz are used to broadcast in English and/or local language. The messages are coded with a header code identified by using alphabets to represent broadcasting stations, type of messages, and followed by two figures indicating the serial number of the message. The time of broadcasting is internationally co-ordinated by areas (NAVAREA) to share the same frequency. The system has been developed by Kenta (France).

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KielRadio system

Kielradio Gmbh proposes a maritime communication system which uses the existing GMDSS MF/HF transmitters to transfer e-mails, data and messages or combine the different communication systems Inmarsat, Iridium, V-Sat, GSM or others with the 'Maritime Communication'.

http://www.kiel-radio.de/

VHF

Very High Frequency Band (VHF)

Voice communication using the maritime VHF band (156.025-162.025 MHz) is prevalent and the primary means of ship-shore, shore-ship and ship-ship communication in the domain. It is used for distress, safety information and general communications. Channel spacing is currently 25 kHz although the use of 12.5 kHz channels on an interleaved basis is allowed to improve spectrum efficiency.

Digital Selective Calling (DSC)

Refer to the same chapter in MH/HF previous chapter.

Voice communication

Voice communication using the maritime VHF band (156.025 to 162.025 MHz) is prevalent and the primary means of ship to shore, shore to ship and ship-to-ship communication in the domain. It is used for distress, safety and general communications. Hand-held units are generally utilized for on-board communications. Primary channels used for distress and safety communications by voice are Ch 6, Ch 13 and Ch 16.

Automatic Identification System (AIS)

Primary purpose of Automatic Identification System

AIS is a TDMA-based data exchange system used by ships and shore authorities. The main purpose of AIS should be to improve the safety of navigation by assisting in the efficient navigation of ships, protection of the environment, and operation of Vessel Traffic Services (VTS), by satisfying the following functional requirements:

- in a ship-to-ship mode for collision avoidance;

- as a means for littoral States to obtain information about a ship and its cargo; and

- as a VTS tool, i.e. ship-to-shore (traffic management).

AIS provides a means for ships to electronically exchange ship data including identification, position, course, and speed with other nearby ships and shore stations. This information can be displayed on a screen display. AIS is intended to assist the vessel's watch keeping officers and allow maritime authorities to track and

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monitor vessel movements. AIS uses VHF Channels AIS 1 (161.975 MHz) and AIS 2 (162.025 MHz) or regional channels in defined geographical areas. Additionally, AIS has the capability for data exchange by application specific messages for navigation and safety related purposes. The VHF Data link (VDL) loading should be considered when using application specific messages.

AIS is also used on Aids to Navigation (AIS AtoN), which can include the incorporation in a physical aid to navigation, or the transmission from an AIS base station. AIS can also be used for the broadcast of navigation information, meteorological and hydrographic data and other application specific messages (AIS ASM). The AIS-SART (Search and Rescue Transmitter) is a locating device. As an element of GMDSS, AIS-SART is used to locate survival craft and distressed vessels. The AIS-SART has no receiver and operates up to 96 hours on a primary battery.

Satellite Data Communication (VHF-UHF/SHF)

Satellite communications in the VHF band are commercially available, but not currently in the maritime VHF band. They can provide services for SMS, weather and tracking.

Satellite Voice and Data Communication (UHF)

The Cospas/Sarsat satellite system dedicated to SAR operates in the UHF band at 406 MHz.

Satellite communications in the UHF band is also commonly deployed on vessels to fulfill general communications purposes. Satellite communication links are capable of supporting analogue and digital voice, broadband connectivity, e-mail, SMS, crew calling, telex, facsimile, remote monitoring, tracking (position reporting), chart and weather updates.

Satellite systems are commercially provided services, which may have global or regional coverage. These systems may be geostationary or non-geostationary. Inmarsat, a geostationary satellite system, is an element of GMDSS for distress alerting, urgency and safety calling.

Other Geostationary systems include VSAT and Thuraya. Non-geostationary satellite systems include Iridium, Globalstar, and Orbcomm.

See more details on the next chapter title "Satellite Communication system technologies".

Terrestrial communication technologies using the UHF/SHF band

Various other communication technologies in the UHF to SHF bands are being used (or considered) for general maritime communications, namely GSM/GPRS, 3G, 4G, Wi-Fi, WiMax, and short range devices like ZigBee and Bluetooth links. These offer the possibility of high speed data transfer. However, it should be noted that the coverage of most of these systems is limited in range and they would therefore be confined to supporting data transfer within a port or harbour environment.

Enhanced Group Call (EGC)

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The Inmarsat-C maritime mobile-satellite system is an element of GMDSS and has an inherent capability, known as SafetyNET, via Enhanced Group Calling (EGC), which allows broadcast messages to be made to selected groups of ship stations located anywhere within satellite coverage. Four geostationary satellites provide near worldwide coverage for SafetyNET except for the polar regions. SafetyNET and NAVTEX are recognized by the GMDSS as the primary means for disseminating maritime safety information. Ships subject to the Safety of Life at Sea Convention (SOLAS) operating outside areas covered by NAVTEX must carry an Inmarsat-C SafetyNET receiver.

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Summary of the characteristics of the main communication systems on board ships (by frequency band)

System	Band	Bandwidth	Mode	Service	Purposes	Range
MF/HF Voice	MF/HF	3 kHz	Analogue voice.	Mobile to mobile. Fixed to mobile. Mobile to fixed.	Distress communication	Long distance, > 250 nm
MF/HF DSC	MF/HF	0.5 kHz 100 bps	Data (Digital)	Mobile to mobile. Fixed to mobile. Mobile to fixed.	Distress alerting	Long distance, > 250 nm
VHF DSC (Ch. 70)	VHF	25 kHz 1200 bps	Data (Digital)	Mobile to mobile. Fixed to mobile. Mobile to fixed.	Distress alerting	Line of sight
VHF voice (Ch. 06/13/16)	VHF	25 kHz	Voice	Mobile to mobile. Fixed to mobile. Mobile to fixed.	Distress communication General voice communication	Line of sight
Two way VHF voice	VHF	25 kHz	Voice	Mobile to mobile.	On scene communication	Line of sight
EPIRB	UHF		Digital	Mobile to satellite	Distress alerting / Location / Homing	COSPAS-SARSAT Satellite; Global coverage
Satellite INMARSAT C	UHF	Tx 1626.5 to 1646.5 MHz Rx 1525.0 to 1545.0 MHz	Digital. Voice and data.	Satellite to earth. Earth to satellite.	Distress alerting, distress communication.	Global coverage
RADAR SART, X-Band	SHF	9.2 – 9.5 GHz	analogue	Mobile to mobile	Homing	Line of sight
NAVTEX	MF/HF	0.5 kHz	Text	Fixed to mobile.	Reception of maritime safety information.	Long distance, > 250 nm Broadcast to mobile only
Narrow band direct printing. (NBDP)	HF	0.5 kHz	Text	Mobile to mobile. Fixed to mobile. Mobile to fixed.	Reception of maritime safety information	Long distance, > 250 nm
EGC	UHF	Tx 1626.5 - 1646.5 MHz Rx 1525.0 - 1545.0 MHz	Digital data.	Satellite to mobile	Reception of maritime safety information (Safety Net)	Global coverage

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System	Band	Bandwidth	Mode	Service	Purposes	Range
HF Voice	MF/HF	3 kHz	Analogue voice. (ALE)	Mobile to mobile. Fixed to mobile. Mobile to fixed.	General voice communication.	Long distance, > 250 nm
Narrow band direct printing. (NBDP)	MF/HF	0.5 kHz	Text	Mobile to mobile. Fixed to mobile. Mobile to fixed.	General text communication	Long distance, > 250 nm
HF Data	MF/HF	0.5 – 3 kHz	Digital data.	Fixed to mobile. Mobile to fixed.	General data communication.	Long distance, > 250 nm
VHF voice (ch. 6/13/16)	VHF	25 kHz	Voice	Mobile to mobile. Fixed to mobile. Mobile to fixed.	General voice communication	Line of sight
VHF data	VHF	25 kHz	data	Mobile to mobile. Fixed to mobile. Mobile to fixed.	General data communication.	Line of sight

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System	Band	Bandwidth	Mode	Service	Purposes	Range
Satellite	UHF	Tx 1626.5 - 1646.5 MHz Rx 1525.0 - 1545.0 MHz	Digital. Voice and data.	Satellite to earth. Earth to satellite.	General voice and data communication.	Global coverage
GSM	UHF		Digital. Voice and data.	Cellular. Mobile-fixed-mobile.	General voice and data communication	Medium range in locality
GPRS	UHF		Digital. Voice and data.	Cellular. Mobile-fixed-mobile.	General voice and data communication	Short range in locality
UMTS/3G	VHF		Digital. Voice and data.	Cellular. Mobile-fixed-mobile.	General voice and data communication	Short range in locality
IEEE 802.11 (Wi-Fi)	UHF/ SHF	11 Mbps 54 - 300 Mbps 54 Mbps	Digital data	LAN Peer-to peer	Internet access	Short in locality < 100 m < 10 km
IEEE 802.16 (WiMax)	UHF/ SHF	75 Mbps	Digital data	LAN Peer-to peer	Internet access	Short range in locality < 50 km
IEEE 802.15.4 (ZigBee)	UHF	20 kbps 40 kbps 250 kbps	Digital data			Short range in locality < 30 km
HF Digital data	HF	10 to 20 kHz.	Data (Digital)	Mobile to mobile. Fixed to mobile. Mobile to fixed.	Binary data communication for navigational and safety related purposes.	40 to 250 nM (>250 sky wave).
VHF Digital data.	VHF mobile	25 to 100 kHz.	Data (Digital)	Mobile to mobile. Fixed to mobile. Mobile to fixed.	Binary data communication for navigational and safety related purposes. (Internet, voice…)	Line of sight

Table 4. Main characteristics of the communication systems (derived from IALA Nav. Comm' Plan

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5.2 Present GMDSS system Components

The following table lists the current communication systems that are in use for the main GMDSS functions. The locating and homing functions are not reported.

Sea area	Distress/Urgency/ Safety Alerting	Distress/Urgency/ Safety Comms	On scene Comms	MSI Promulgation	General comms
A1	VHF DSC EPIRB	VHF R/T	VHF R/T	NAVTEX SafetyNET	VHF R/T
A2	VHF DSC MF DSC EPIRB	VHF R/T MF R/T			VHF R/T MF R/T/NBDP
A3	VHF DSC MF DSC HF DSC Inmarsat EPIRB	VHF R/T MF R/T HF R/T/NBDP Inmarsat		NAVTEX SafetyNET HF MSI	VHF R/T HF/MF R/T/NBDP Inmarsat
A4	VHF DSC MF DSC HF DSC EPIRB	VHF R/T MF R/T HF R/T/NBDP		HF MSI	VHF R/T HF/MF R/T/NBDP

Table 5. Current GMDSS system components

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The following table presents the communication equipments – both GMDSS and non GMDSS - used for each of the GMDSS defined areas.

Area number	Area Description	Equipment used
Area 1	An area covered by a coast station using VHF DSC, typical 30 nautical miles (56 km) to 40 nautical miles (74 km) from the Coast Station.	VHF, NAVTEX, Cell phone (*)
Area 2	An area covered by a coast station using MF DSC typical 180 nautical miles (330 km) offshore during daylight hours. Around 400 nautical miles (740 km) offshore during night time.	MF, HF, NAVTEX, Satellite services
Area 3	An area outside areas A1 and A2, covered by the Inmarsat GMDSS service, which is about latitude 76 Degree NORTH and SOUTH, but excludes A1 and/or A2 designated areas.	Inmarsat B, C or F77 (eg. SafetyNet)
Area 4	An area outside Sea Areas A1, A2 and A3 This is essentially **the polar regions**, north and south of about 76 degrees of latitude, excluding any A1 or A2 areas.	COSPAS SARSAT, MF, HF, Iridium (*)

Table 6 - Navigation areas classification and type of communication (* : non GMDSS presently)

The following Figure 4 illustrates the complementary capability of Iridium to cover the INMARSAT communication polar gap.

5.3 Satellite Communication system technologies

This chapter provides a comparative description of the satellite communication systems. Their strengths and weakness are presented. The future trends are also drawn.

Systems	Main functions in the maritime domain	Strengths	Weaknesses
Inmarsat-C SafetyNet	E-mail/telex/fax GMDSS : locating, distress alerting, on scene comm', 0.6 kbps	Already on-board ships (monopoly for satellite GMDSS communication)	Polar regions not covered Old technology, no data encryption

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Inmarsat FleetBroadband	Voice, Data, SMS (Internet, Email, Video) Maritime Safety Data Service (MSDS with Emergency Calling facility for non-SOLAS ships) 150 up to 432 kbps	Integrated applications to reduce complexity for the ship operators Commercial offers for low and high data volume	Permanent connection (Internet) Not accessible to small ships (terminal price)
Inmarsat Global Xpress	Same as Inmarsat FleetBroadand (150 to 432 kps, voice, IP data) with higher speeds Applications integration		
Iridium SBD	Data transmission 2.4 kps, 2 kbytes	Global coverage Data encryption Working towards GMDSS compliance Commercial offers for low and high data volume	License restriction over North Korea, China… Some delays with the present constellation (few mn) Not accessible to small ships (terminal price)
Iridium Rudics	Data transmission 2.4 kps, large volume of data		
Iridium Next	Data transmission High-speeds, few Mbps (L & Ka-bands)		
Orbcomm	Short bursts <100 bytes at 2.4 kbps (uplink) and 4.8 kps (donwlink)	Limited coverage (high latitudes but also South Pacific or Indian oceans are excluded) Latency up to few minutes	Present market is not on the maritime sector
VSAT	Voice, IP, data (inet, fax, E-mai, video) Up to 2 Mbps downstream, 0.512 Mbps upstream	Attractive low cost offers for high data volumes Offshore applications	Complexity of installation onboard Complexity of operations Limited coverage
GlobalStar	Voice, SMS, Roaming, Positioning (10 km), fax, data, E-mail Low cost SAR or tracking transceivers	-	Limited coverage (GSM or CDMA mobile phone networks) mainly continental
Turaya	Regional telephone service (GSM, GPS, Geosat)	GSM roaming services (110 countries) Dual phone using GSM and satellites	Limited coverage mainly Europe, Africa, Middle East Very small high seas areas covered Latency up to few minutes (including GSM roaming)
Gonets-D1M	http://english.gonets.ru/ http://gonets.ru/eng/index.html	-	-

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Polar Star	Regional (Russia, Arctic) mobile broadband access, HEO satellites, Ka-band few mbps Internet, e-mail, tel., TV	Russia and Arctic region dedicated	Presently 1 over 3 satellites is launched
PCW (Polar Comm' & Weather)	Comm', navigation and met. Data 2 ways, high data rate 2 HEO sat., operationnal in 2017	Canada	Limited coverage

Table 7. Existing communication technics/systems for maritime applications

For the e-navigation and the EfficienSea 2 project, the IP connectivity of the systems is attractive (VSAT, INMARSAT, Iridium NEXT…).

Satellite communications general trends

A current trend in maritime satellite communication is a need for increasingly large quantities of data for transmission. Today merchant vessels, offshore and cruise ships need to transfer increasing quantities of data. Shipping companies that are under pressure to manage cost and large fleet sizes are turning to applications for weather, routing, monitoring, and security to gain an advantage over the competition. Seafarers are increasingly demanding and expect connectivity to stay in touch with family and friends. To respond to this, ship owners are actively adopting satellite communication to attract and retain skilled crew in this highly competitive marketplace. Providing comfort whilst onboard vessels, be it for cruise ships passengers or merchant vessels/ offshore companies staff, is increasingly important. The emergence of on board hybrid networks with VSAT and MSS has enabled owners to provide the connectivity required to support changing communication usage patterns. Statistics show that cruise vessels, tankers and supply vessels have been quick to adopt onboard broadband. The return of the Non-Geo Satellites is also set, as it provides improved reliability, good quality, and cost reduction. Iridium looks to position itself to take the market share within this market.

Satellite communications in the context of EfficienSea 2

The EfficienSea 2 project is focused on a new communication infrastructure that intends to revolutionize the information sharing. E-navigation solutions, respectively e-maritime solutions will be implemented and tested, It can be to reduce the risk of accident or increase the ship traffic efficiency, respectively to provide automatic reporting. An important challenge is to get access to information service at a reasonable price. The maritime cloud and the roaming technologies will play a key rule. The seamless roaming mechanism will permit to select the most suitable communication link. For most of the EfficienSea 2 scenario (see Chapter 0), the use of the satellite communication link will preferably be used when no other terrestrial communication system is available.

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An example of terrestrial communication link limitations with a ship is given in the following figure.

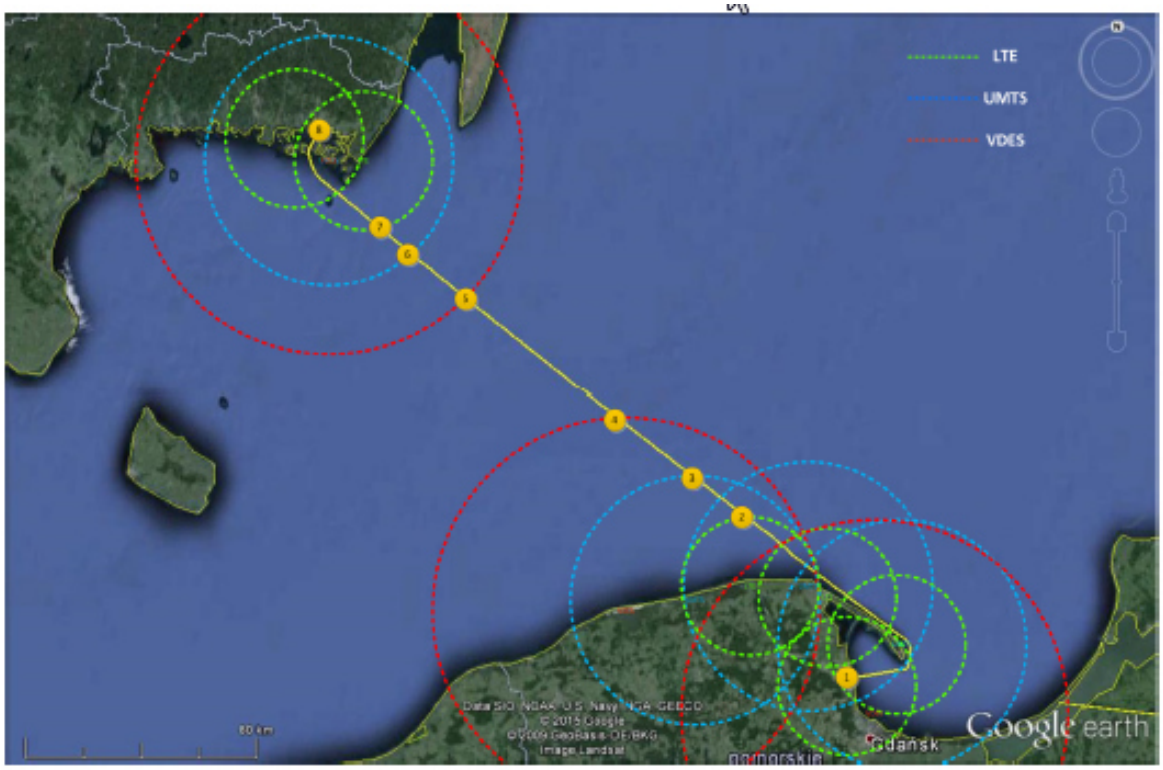

Figure 3. Approximate ranges of the terrestrial radiocommunication systems (red circles) along the ferry route from Gdynia (Poland) to Karlskrona (Sweeden) accross the Baltic Sea (source : K. Bronk, EfficienSea 2, D2.7).

5.4 Iridium mobile satellite system as a GMDSS service provider

Inmarsat was the sole provider of maritime satellite communications services when the GMDSS regulations were original developed, and it has remained the sole certified satellite provider in the early 1990s. In 2007, the IMO assembly voted to approve amendments to the SOLAS convention providing guidelines for the evaluation, recognition, review and oversight of alternative MSS providers to become qualified for GMDSS. This was largely driven by increased interest in arctic shipping (sea area A4), where currently patchy GMDSS coverage is offered by HF radios, and ship operator interest in developing a competitive market. Iridium, as of June 2013, has asked the IMO Maritime Safety Committee to verify that the Iridium satellite constellation meets the necessary criteria to become a GMDSS service provider – opening the way for Iridium to offer GMDSS compliant terminals based on their Short Burst Data (SBD) service. During the June 2013 meeting of the IMO Maritime Safety Committee reported the recognition of the Iridium mobile-satellite system as follows: “ 9.22 The Committee considered the notification by the United States (MSC 92/9/2) of the application

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of the "Iridium" mobile-satellite system for recognition and use in the GMDSS. The United Sates informed the Committee that it intended to provide the competent Sub-Committee with the necessary information to enable the Sub-Committee to verify that the "Iridium" mobile-satellite system meets the criteria of resolution A.1001(25), and to provide a recommendation to the Committee concerning the recognition of that system for use in the GMDSS." In July 2014, the Iridium application to the International Maritime Organization (IMO) for the provision of mobile satellite communications in the Global Maritime Distress and Safety System (GMDSS) was reviewed by the IMO Sub-Committee on Navigation, Communications and Search and Rescue (NCSR). A technical annex that contents the system definition and the justification with regards to the GMDSS criteria and requirements has been provided to the IMO sub-committee on navigation communication and search and rescue (NCSR) for analysis of application in March 2015. Overwhelmingly, the delegates stated support for the United States position to advance Iridium's application to the next stage for evaluation. Final approval will be up to the Maritime Safety Committee, following review of the experts' report by NCSR, which is expected by mid-2016.

A major advantage of the Iridium Satellite LLC (Iridium) is that it is the only mobile voice and data satellite communications network that spans the entire globe. A technology innovator and market leader, Iridium enables connections to and from anywhere, in real time. Iridium's 66 low-earth orbiting (LEO) cross-linked satellites form the world's largest commercial satellite constellation, and operate as a fully meshed network, supported by multiple in-orbit spares. Covering continents, oceans, airways and polar regions, Iridium is ideally suited to provide critical communications for the maritime, aviation, transportation, emergency services industries as well as government agencies.

Iridium 66 satellites constellation

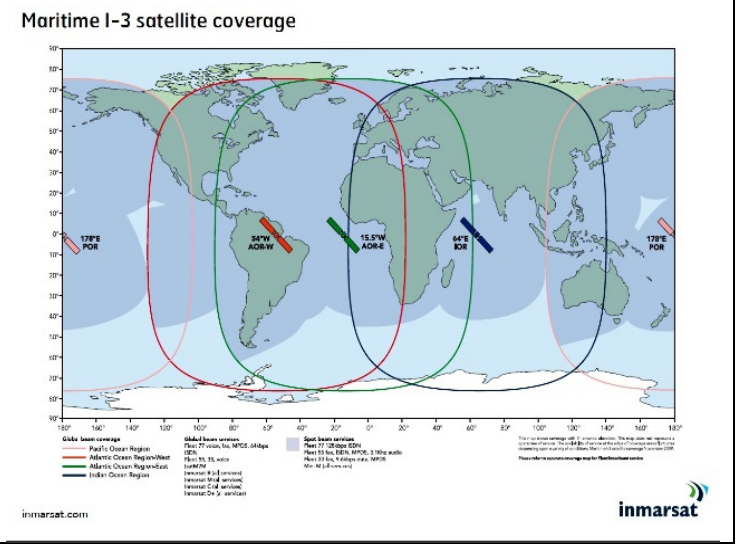

Figure 4. Left : the Iridium constellation with full global coverage
Right : the INMARSAT constellation with its footprints and high latitudes coverage gaps

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The Iridium network is a satellite-based Global Mobile Personal Communications by Satellite System (GMPCS) supporting fully global, wireless digital communications. Iridium provides voice, data, paging, broadband, broadcast and messaging (SMS) services to mobile subscribers using a vast array of user terminals, installed on vehicles, vessels, aircraft or deployed in a remote location. Network latency for the delivery of a ship-to-shore call or message is less than 60 seconds more than 95 percent of the time, for users that have a dedicated connection to an Iridium gateway(s). A call flow diagram for a ship-to-shore distress call or distress alert is provided in the following figure.

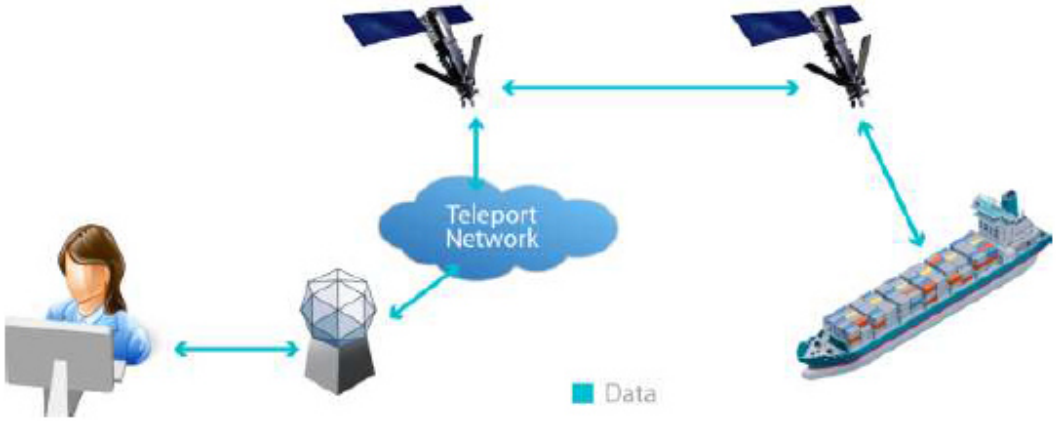

Figure 5. Shore-to-ship distress relay alerts/calls via Iridium

Iridium currently supports more than 660,000 subscribers worldwide, spanning a variety of industries, with more than 50,000 subscribers in maritime industries. Of the 50,000 maritime subscribers, approximately 10,000 devices are used for voice and/or data communications aboard ships regulated under SOLAS Chapter IV.

The Iridium satellite constellation, including the on-orbit spares, is forecast to continue service until at least 2018; and recent third -party analysis shows that the constellation could support service for several years beyond then. However, Iridium NEXT the second-generation satellite constellation,as Iridium NEXT will complement the satellite vehicles and the complement of on-orbit spares extending the Iridium network beyond 2025.

5.5 Other considerations on the GMDSS modernization

It is to be noted that NCSR experts in charge of reviewing the GMDSS modernization future options have pointed out some issues especially on the addition of satellite systems that were not anticipated. Such issues are relevant to consider in the case of the EfficienSea2 project which intends to optimize communication systems (cf NCSR 3/17 Oct. 2015).

Interoperability

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Concerns is about interoperability, referring to the ability to conduct ship-to-ship, ship-to-shore, and shore-to-ship communications without regard to differing satellite systems in use by the communicating stations. Inevitably, the expected result is the increased system complexity. For instance, it is not necessary for a Rescue Coordination Centre (RCC) to have an Inmarsat terminal to communicate with a ship using the Inmarsat satellite system. The connection can be completed through the Public Switched Telephone Network (PSTN) although dedicated land lines may be used. Similarly, current SafetyNet Maritime Safety Information (MSI) providers do not need to have Inmarsat terminals to provide their broadcasts.

Cost implications

Coast earth stations and ships typically subscribe to Inmarsat services and pay additionally for the amount of voice and data services they receive or transmit, other than those listed in 4.5 and 4.6. The addition of new satellite service providers should allow users to compare service plans and charges, which might result in reduced expenses for them, and might result in a wider range of available services.

Cost implications for SAR authorities should not change since they should not be charged for distress traffic. They should also not have to install additional land stations, since they will be able to communicate with ships served by new GMDSS satellite service providers, using existing hardware and systems since they should all be interoperable. However, they may find that it is more efficient to have their own land station for each GMDSS satellite service provider.

There could be cost implications for MSI providers. With the exception of urgent ship-to-shore navigational and meteorological danger reports, they pay Inmarsat for the SafetyNet broadcasts. It is to be expected that any new satellite service provider would impose comparable charges. Since the MSI providers would have to provide their broadcasts over all GMDSS satellite systems, the addition of one new satellite service provider could double their costs. A third could triple their costs.

ITU List V and MARS Database

Resolution A.887(21) should be revised to apply to all GMDSS satellite service providers. It should also be clarified as to whether or not satellite service provider identities should be included in databases such as List V and MARS, or whether registration with the satellite service provider is sufficient, especially for SAR purposes.

Impact of space weather on satellite communications

This matter is particularly relevant for Northern latitudes. It is one of the topic of EfficienSea2 task 2.2.

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6. Novel communications systems

6.1 Digital data communication on MF/HF

Ref. polar region, recomm' ITU-R M.1798-1

Kiel Radio is one the companies that provides commercial services (see also chapter 5)

6.2 NAVDAT (Navigational Data) (MF band)

The NAVDAT is an MF radio system, used in the maritime mobile service, operating in the 500 kHz band for digital broadcasting of maritime safety and security related information from shore-to-ship. The WRC-12 approved the worldwide exclusive usage of the frequency band 495 - 505 kHz for the maritime mobile service. The NAVDAT system utilizes an OFDM modulation in this 10 kHz bandwidth which provides a flow rate of about 15/25 Kbit/s (more than 300 times the NAVTEX transmission), featuring:

- Possibility to transmit any type of text, graphs, pictures, data etc with encryption if required;
- Automatic reception;
- Possibility to use Single Frequency Network (SFN) technology, with no need for time slot allocation on the same frequency.

The global architecture of the NAVDAT is similar to the NAVTEX and the coverage is approximately 250/350 NM from coast station (see also ITU-R M.2010).

On sea tests have been made in France. The network of transmission antennas is under development. However, the NAVDAT is not in the scope of EfficienSea2 as there is no mature enough plan to update the NAVTEX ground infrastructure in the areas of the envisaged test beds.

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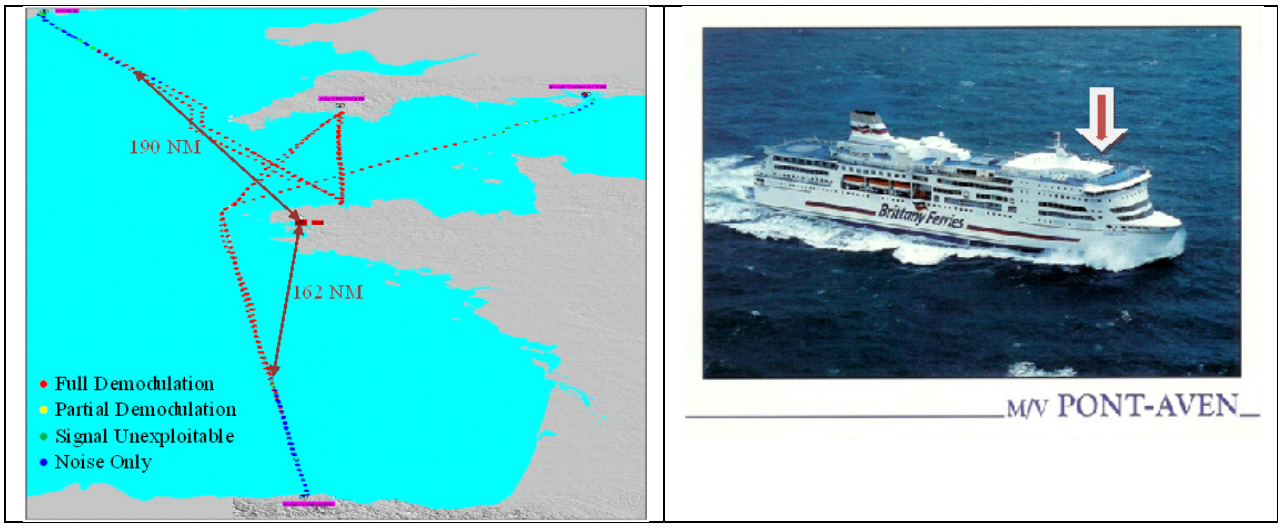

Figure 6. On sea tests of the NAVDAT system (Kenta source)

6.3 VDES

VDES general presentation and implementation status. The VDES concept emerges from the assessment made at IALA that AIS is a success story but the main objectives of the system may be compromised if nothing is done to control the multiple uses of the dedicated frequencies. The issue has been summarized as follows. The AIS is now well recognized and accepted as an important tool for safety of navigation and is a carriage requirement for SOLAS vessels (Class-A). However, because of its effective and useful technology, the use of AIS is expanded to vessels not complied with the carriage requirement (Class-B) and other applications such as Aids to Navigation (AtoN), Application Specific Messages (ASM), Search and Rescue Transmitter (SART), Man Over-Board unit (MOB) and EPIRB-AIS. This expanding use of AIS technology has caused significant increase in VHF Data Link (VDL) loading which has become an active concern in IMO andITU. Simultaneously, because of increasing demand of radio spectrum for digital communication such as mobile phone and data, ITU now requests more efficient and effective use of radio spectrum. It was the opportunity to design a new integrated terrestrial and satellite communications system to exchange maritime information between ships, and between ship and shore.

Using extending VHF channels, the VDES will provide higher data rates (up to 32x) than the present AIS and will become core element of VDES. Furthermore VDES network protocol should be optimized for data communication so that each VDES message is transmitted with a very high confidence of reception. Consequently VDES will allow more efficient and effective use of marine VHF spectrum.

The VDES is envisioned to operate as an integrated system (to include AIS, Application Specific Messages (ASM) and VHF Data Exchange (VDE), in ship-ship and ship-shore communications, including satellite uplink and downlink). The system will give its highest priority to the automatic identification system (AIS) position reporting and safety related information.

The VDES functions and the frequency usage are illustrated pictorially in the following figure.

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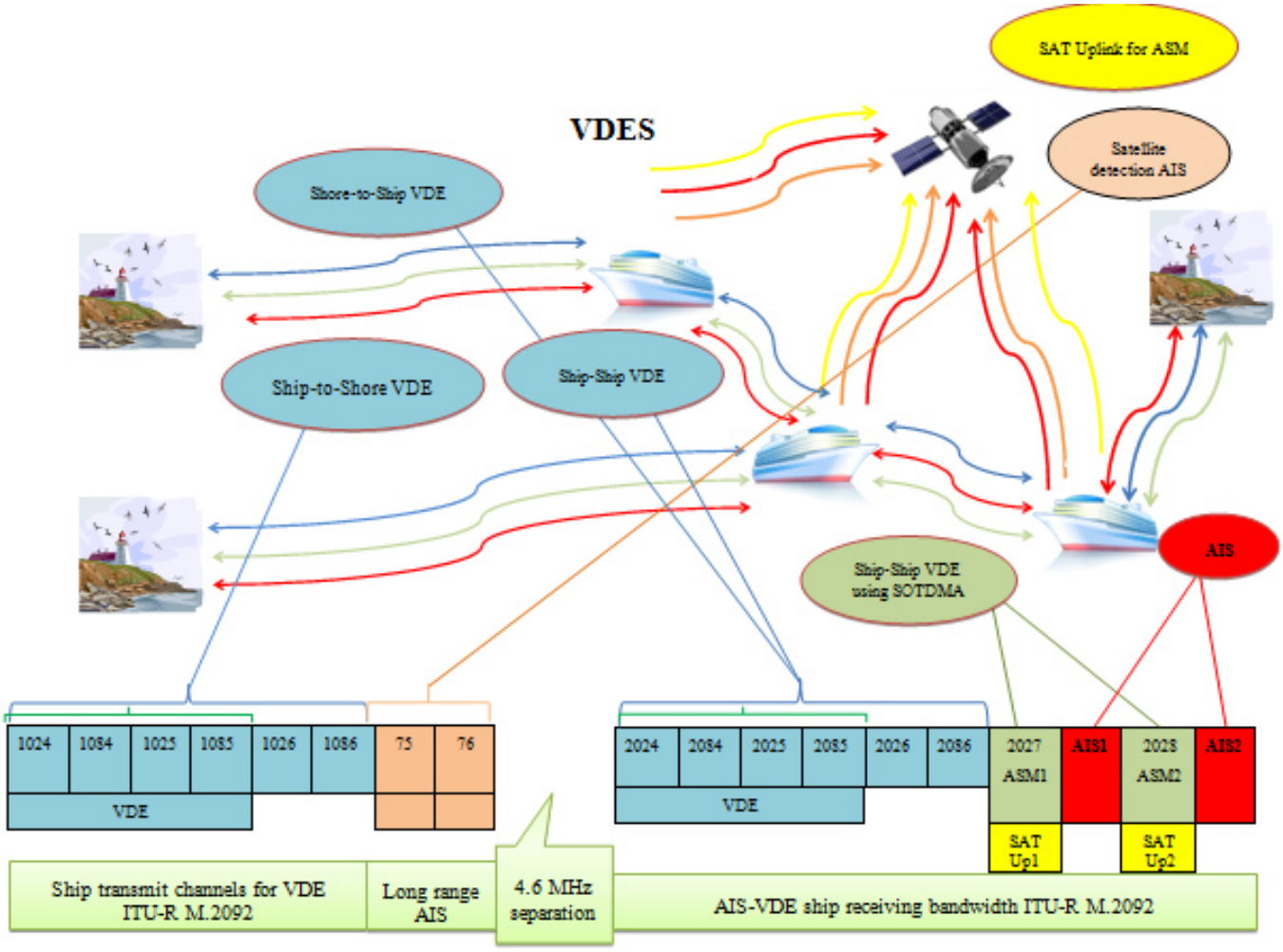

Figure 7. VHF data exchange system functions and frequency usage (status on Jan. 2016, sourec C. Rissone, ANFR)

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This previous figure and the following table depict the present status of the VDES and the frequency bands that have been defined and presented during the November 2015 world Radio Conference (WRC-15).

RR Appendix 18 channel number		Transmitting frequencies (MHz)	
		Ship stations (ship-to-shore) (long range AIS) Ship stations	**Coast stations Ship stations (ship-to-ship)**
AIS 1		161.975	161.975
AIS 2		162.025	162.025
75 (long range AIS)		156.775 (ships are Tx only)	N/A
76 (long range AIS)		156.825 (ships are Tx only)	N/A
2027 (ASM 1)		161.950 (2027)	161.950 (2027)
2028 (ASM 2)		162.000 (2028)	162.000 (2028)
24/84/25/85 VDE		100/150 kHz channel (24/84/25/85, lower legs (VDE) merged) Ship-to-shore (24/84/25/85/26/86,)	100/150 kHz channel (24/84/25/85, upper legs (VDE) merged) Ship-to-ship, Shore-to-ship (24/84/25/85/26/86)
24 84 25 85		157.200 (1024)	161.800 (2024)
		157.225 (1084)	161.825 (2084)
		157.250 (1025)	161.850 (2025)
		157.275 (1085)	161.875 (2085)
		157.300 (1026)	161.900 (2026)
		157.325 (1086)	161.925 (2086)

Table 8. VDES frequency bands in the VHF maritime mobile band (Appendix 18)

The technical specifications of all the VDES components are under definition at IALA. In particular, they include the specifications of the signal structures for the terrestrial part or VDE-TERR and the satellite part or VDE-SAT. An important consideration is the cohabitation between the sub-systems and several options are envisaged for sharing the services..The WRC-15 accepted the VDES terrestrial specification as designed by IALA expert team. The satellite component is to be consolidated for the next WRC in 2019. In particular, technical studies and tests are required to demonstrate the feasability of VDE-SAT. Frequency bands are available for such activities.

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VDE-TERR component

The VDE-TERR will be an important contribution to the EfficienSea2 project. The task 2.1 is dedicated to the VDES. This task will provide momentum into the introduction of that novel and globally interoperable and potentially cost free ship-to-ship and ship-to-shore digital communication link. This communication links is envisaged to be dedicated to data transfer, in particular the reception of public service safety information and operational data exchange related to the safety and efficiency of shipping. The partners will develop proposals and tests for channel access, modulation techniques and communication protocols. In addition hardware prototypes will be developed in a lab environment as well as in live sea trials.

VDE-SAT component

The VDE Satellite Downlink is assumed to support the following services:

- Downlink multicast multi-packet data transfer;
- Shore originated unicast multi-packet data transfer via satellite.

Only Low Earth Orbit (LEO) satellites are considered with 600 km altitude as typical.

The main VDE-SAT activities in Europe are lead by the ESA, the European Space Agency. ESA started studies on the satellite system definition and demonstration on the scope of ARTES telecommunication programs.

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One study focuses on the user needs, on system requirements and the mission concept. Another study consists in a demonstration of the VDE-SAT downlink in order to verify in-orbit the signal characteristics. Finally, ESA has started a study for the development of a cost effective solution for a VDE-SAT user terminal on board vessels.

The following figure summarizes the envisaged VDE-SAT test demonstration on real operating environment.

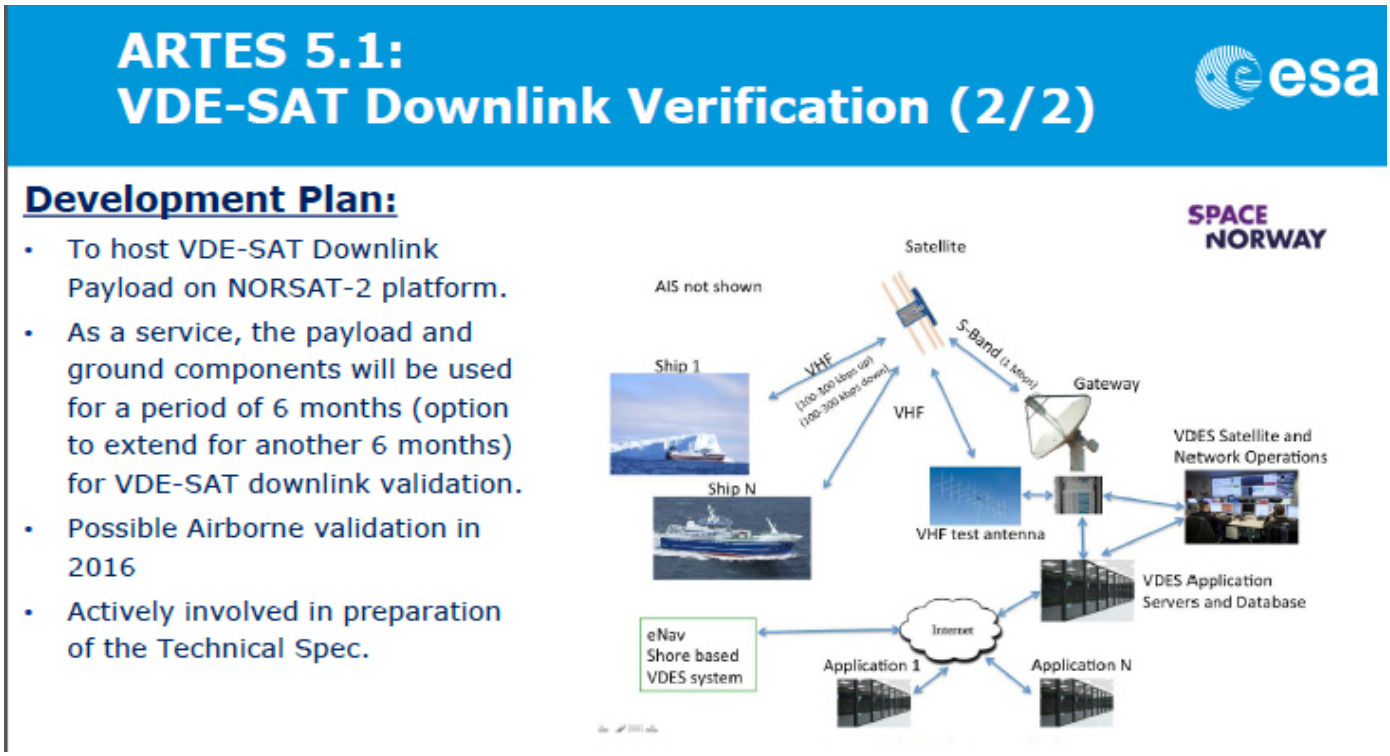

Figure 8. ESA project for a VDE-SAT downlink demonstration

The hereafter table summarizes some typical maritime information that may transit via a LEO satellite on the VDES. The use of satellite is justified particularly justified on high seas or over the Arctic which is identified as a present gap on maritime communications.

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Nature of info	Services	Products
MSI from satellite to ship	Weather, ice	Charts, bulletins
	Hazards	Dangers identification & location (containers, offshore structures, pieces of wood, drifting buoys, cetacean...)
	Area notice	Restricted maritime area (in complement to nautical publications)
	SBAS_corrections	Long term variation corrections (satellite ephem. & clocks, ionosp)
Report from ship to satellite	Weather report from ships	in-situ observations, WMO/VOS Program (ASM + ECDIS mangement to reduce manual operations)
	Dangers at sea	cf Hazards
	Extract of Voyage data recorder (VDR)	data report, complementary information (my last positions, vessels in vicinity)
	Position report from ship	Dangerous cargo freight, Piracy: victim or witness report
SAR	SAR Operations	distress alert, situation report (Sitrep) RCC acknowledgment

Table 9. Typical maritime applications for the VDE-SAT (high seas or Arctic)

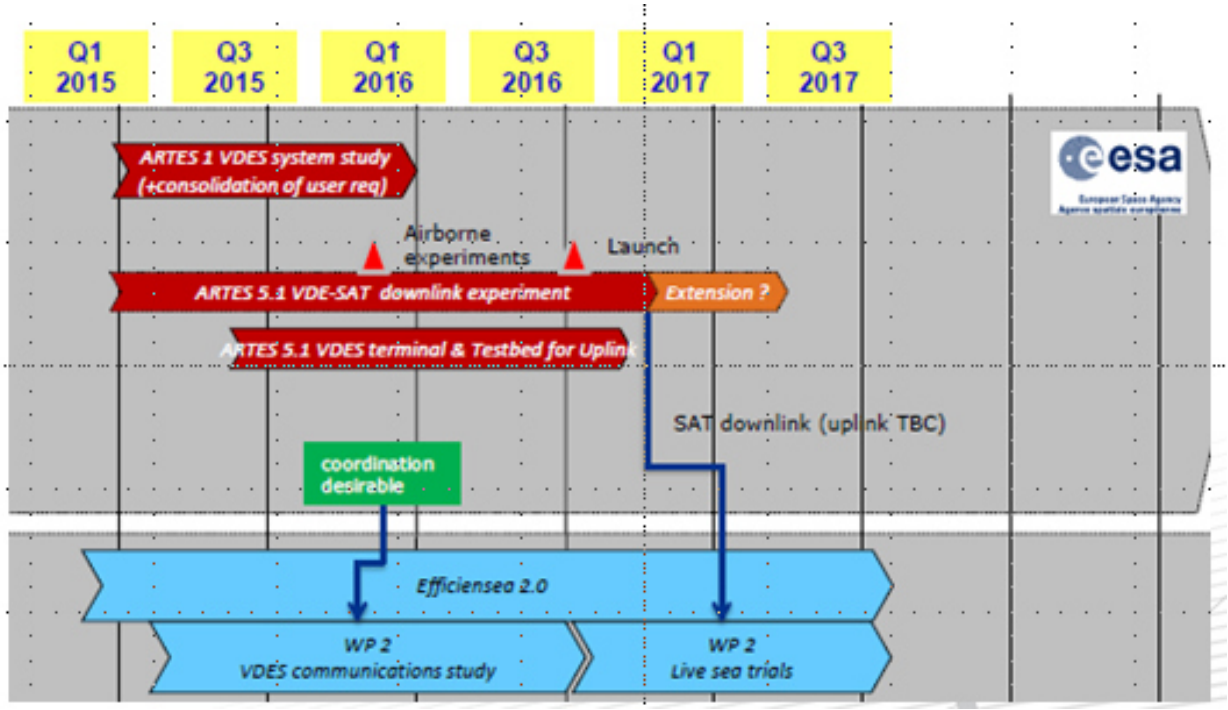

Figure 9. Plans for the ESA VDES activities (in red) and coordination with EfficienSea 2 activities (in blue) (Nov. 2015)

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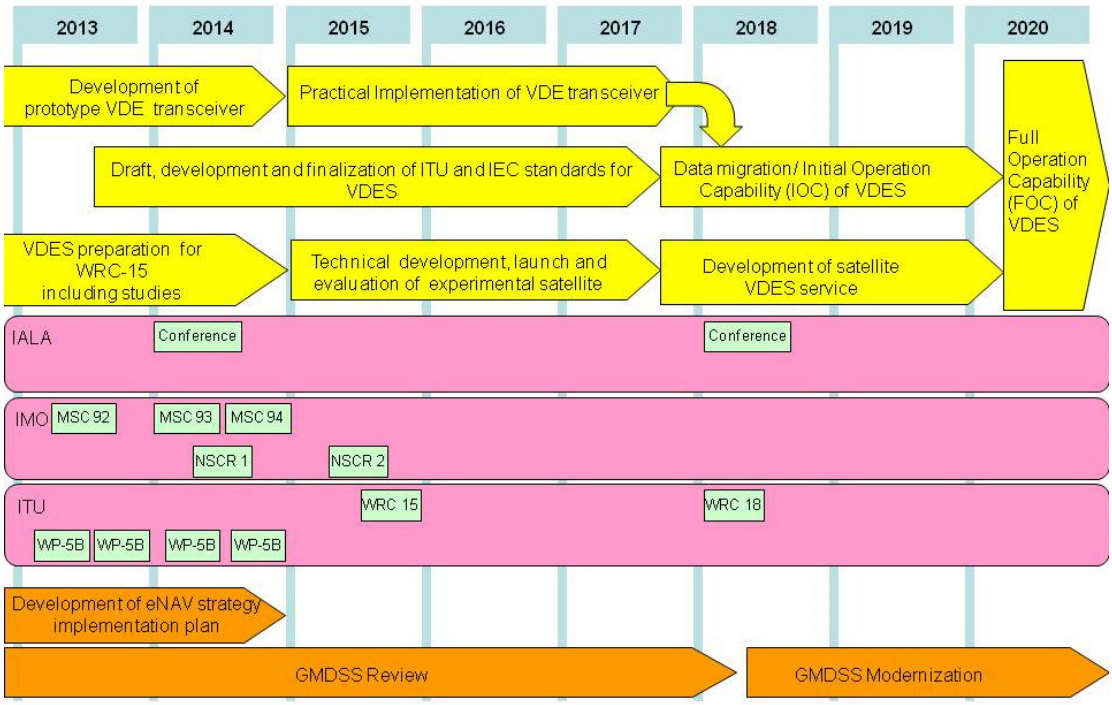

Novel communication systems and the GMDSS modernization

Hereafter are some conclusions of the joint IMO/ITU Expert Group on Maritime radiocommunication matters last recent meeting, 5-9 October 2015.

AIS
See VDE hereafter chapter

NAVDAT
The SOLAS chapter IV should be revised to allow ships to use NAVDAT services in addition to, or in place of, NAVTEX, in places where NAVDAT would be available. It is another mean of receiving MSI.

VDES
VDES is another e-navigation technology in development that uses the VHF maritime frequencies. It is capable of exchanging Application Specific Messages (ASM), facilitating numerous applications for safety and security of navigation, protection of marine environment, efficiency of shipping and others. VDES will prospectively have a significant beneficial impact on the maritime information services including Aids to Navigation and VTS in the future. It is another mean of receiving MSI especially in remote areas.

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7. EfficienSea2 project and communication requirements

A large list of maritime services are concerned by the EfficienSea 2 project. The complete list is given hereafter.

Services to improve navigational safety and efficiency
Nautical charts based on S-101
MSI & NM
METOC
Smart buoy
Ice charts
Route exchange
No-go area/comfort zone
Generic route optimization services
Services to arctic navigation and emergency response
Arctic live position sharing
Crowd-sourcing of ice information
Arctic SAR tool
Space weather forecast
Services to decrease administrative burden
Automated VTS/SRS reporting
Reliable port reporting
Reliable port information
Services to improve environmental monitoring & enforcement
Emission monitoring solution
Enabling actions to improve availability and accessibility
Communication framework/Maritime Cloud
Communication channels and other technologies

Table 10. Complete list of EfficienSea 2 services (source : D1.5)

Each service can be associated to a one of the Maritime Service Portfolio (next table).

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EfficienSea 2	Maritime Services
MSP 1	VTS Information Service (IS);
MSP 2	VTS Navigation Assistance Service (NAS)
MSP 3	VTS Traffic Organization Service (TOS)
MSP 4	Local Port Service (LPS)
MSP 5	Maritime Safety Information (MSI) service
MSP 6	Pilotage Service
MSP 7	Tugs Service
MSP 8	Vessel Shore Reporting
MSP 9	Telemedical Maritime Assistance Service (TMAS)
MSP 10	Maritime Assistance Service (MAS)
MSP 11	Nautical Chart Service
MSP 12	Nautical Publications Service
MSP 13	Ice Navigation Service
MSP 14	Meteorological information service
MSP 15	real-time hydrographic and environmental information
MSP 16	Search and Rescue (SAR) Service
MSP 17	Remote monitoring of ships systems
MSP 18	Offshore activities
MSP 19	Fishing activities
MSP 20	Leisure boating
MSP 21	Coastal surveillance

Table 11. Maritime Service Portfolio

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7.1 Generic services and associated communication requirements

A restricted number of services are considered as generic use cases for the communication analysis in the scope of that document (Table 12).

Nota :

The communication requirements associated to use cases are provided in a separate document titled

015-12-17 -Service Communication Requirements WP3-WP2 - CLS_v1.xlsx

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Project task	MSP	UseCase	
Task 5.1	MSP 8	Port Reporting	Port Reporting (prior to port entry)
	MSP 8		Port Reporting (prior to port departure)
Task 4.2	MSP 5	MSI & NM	MSI & NM
Task 4.2	MSP 5		MSI & NM (Hydro data)
Task 4.3	MSP 14	METOC	
Task 4.4	MSP 11	Sea Charts	Sea Charts
Task 4.4	MSP 11		Sea Charts (commercial serv.)
Task 4.5	MSP 5/14/15/18	Smart buoys	Smart buoy Broadcast Service
Task 4.5	MSP 3/18/(others?)		Smart Buoy Management Service (AtoN)
Task 4.6	MSP 1/8	Route data	Route plan Active route
Task 4.6 Task 6.1	MSP 1/2/3/4/6/13/14		Route check Route infos - suggestion - alerts Route optimisation & negocation
Task 4.6	MSP 1		Route information (optimization, revision, incident, hazard)
Task 4.7	MSP 13	Ice Charts Services	Ice Cart Service - charts
			Ice Cart Service - charts
			Ice Cart Service - forecasts
			Ice Cart Service - forecasts
Task 5.2	MSP 4	Port Information	Port Information
Task 5.2	MSP 4		Port Information Commercial services
Task 5.3	MSP 8	Emission Monitoring	
Task 6.2	MSP1	VTS & SRS	VTS Reporting (see also Route info task 4.6)
Task 6.2	MSP8		SRS Reporting
Task 6.3	MSP 10/16	Self-organizing emergency (Arctic area)	

Table 12. Generic use cases for which communication requirements are analyzed

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The two following tables are extracts of the per use case communication requirements (xls file). They show the main technical characteristics of the required link.

Nota : the technical characterization of the communication links results from the collection of inputs from other tasks of the projects. A significant contribution also comes from the IALA e-nav WG3 that focuses on Maritime Communications. The approach followed by that group lead by the Australian Maritime Safety Authority to define the VDES user needs largely inspired the approach followed to build that table.

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UseCase		Data to be available electronically		Interaction Type			Cyber Security			Link Requirements			
		Data Source	Usage (what equipment) (what endpoint)	P2P	Multicast , Point to many, with ack.	Broadcast , Point to many, No ack.	Authentication (digital signing)	Confidential (Encrypted)	Client Authentication	Transaction Frequency	Information Size (per transaciton) (maximum)	Transfer per day per site kB	Latency
Port Reporting	Port Reporting (prior to port entry)	on-board admng	Shore Authorities	x			x	x		Depend of Type of Operation 1 per day ?	32 x 1 K Byte	32 x 1 K Byte	
	Port Reporting (prior to port departure)	on-board admng	Shore Authorities	x			x	x		Depend of Type of Operation 1 per day ?	32 x 1 K Byte	32 x 1 K Byte	
MSI & NM	MSI & NM	Shore Authorities	Ships	x			x	x		Depend on info type & priority	1-10 kByte	TBD	
	MSI & NM (Hydro data)	Shore Authorities	Ships	x			x	x		Depend on info type & priority	High data volumes > 1 Mb		
METOC		Commercial entity	Ships	x			x	x	x	On request	?		1-4 hours (?)
Sea Charts	Sea Charts	Shore Authorities	Shpis	x		x	x			On request On event (change)	< 1-10 kBytes (images ?)	< 1-10 kBytes	few hrs to several weeks
	Sea Charts (commercial serv.)	Commercial entity	Shpis	x	x	x	x		x	On request On event (change)	< 1-10 kBytes (images ?) (hydro data ?)	< 1-10 kBytes	few hrs to several weeks

UseCase		Candidate Carriers										
		Priority (Distress, Urgent, Safety, Routine General)	Wi-fi	WiMax	Cellular networks (2G, 3G, LTE)	AIS/ASM	VDE-TERR	MF/HF NBDP	MF/HF digital data service (NAVDAT but assumption of coastal stations updates)	Inmarsat	Iridium	VSAT (with restriction of coverage limitations)	VDE-SAT
Port Reporting	Port Reporting (prior to port entry)	Routine	x	x	x		x			x	x	(x)	x
	Port Reporting (prior to port departure)	Routine	x	x	x		x		(x)	x	x	(x)	
MSI & NM	MSI & NM	Routine Urgent (on event)	x	x	x	ASM	x		(x)	x	x	(x)	x
	MSI & NM (Hydro data)	Routine Urgent (on event)	x	x	x		x		(x)	x	x	(x)	x
METOC		Routine Urgent (on event)	x	x	x		x			x	x	(x)	x
Sea Charts	Sea Charts	Routine Urgent (on event)	x	x	x	ASM	x		(x)	x	x	(x)	x
	Sea Charts (commercial serv.)	Routine Urgent (on event)	x	x	x	ASM	x			x	x	(x)	x

Table 13. Typical communication requirements for some EfficienSea2 use cases (see also the complete xls doc, annex B)

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7.2 The communication management in the maritime cloud

The Maritime cloud is defined as a communication framework which enables efficient, secure, robust and trouble-free exchange of information between each and every authorized maritime entity, using available communication systems. Its architecture is hereafter depicted and described in a conceptual model (EfficienSea 2 - D3.2 Maritime cloud conceptual model).

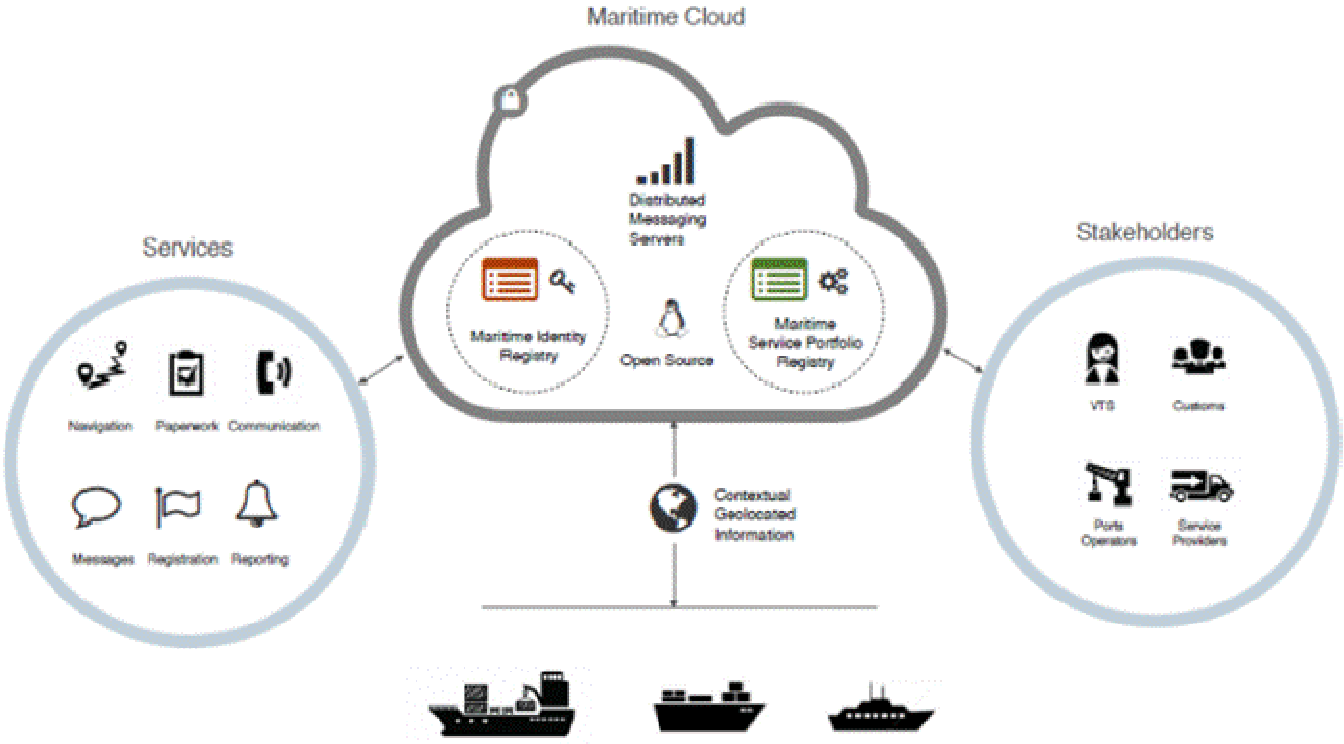

Figure 10. Maritime Cloud general architecture

(https://dma-enav.atlassian.net/wiki/display/MCCT/Maritime+Cloud)

The maritime cloud is a facilitator connecting Stakeholders in the Maritime Domain. Services can be easily registered, discovered and used. Identities can be verified and used to digitally sign communication. Messages can be exchanged between components connected to the cloud, Components connected to the cloud call the "operator"/service registry asking for a service, for example a MMS (Maritime Messaging Service, Figure 11).

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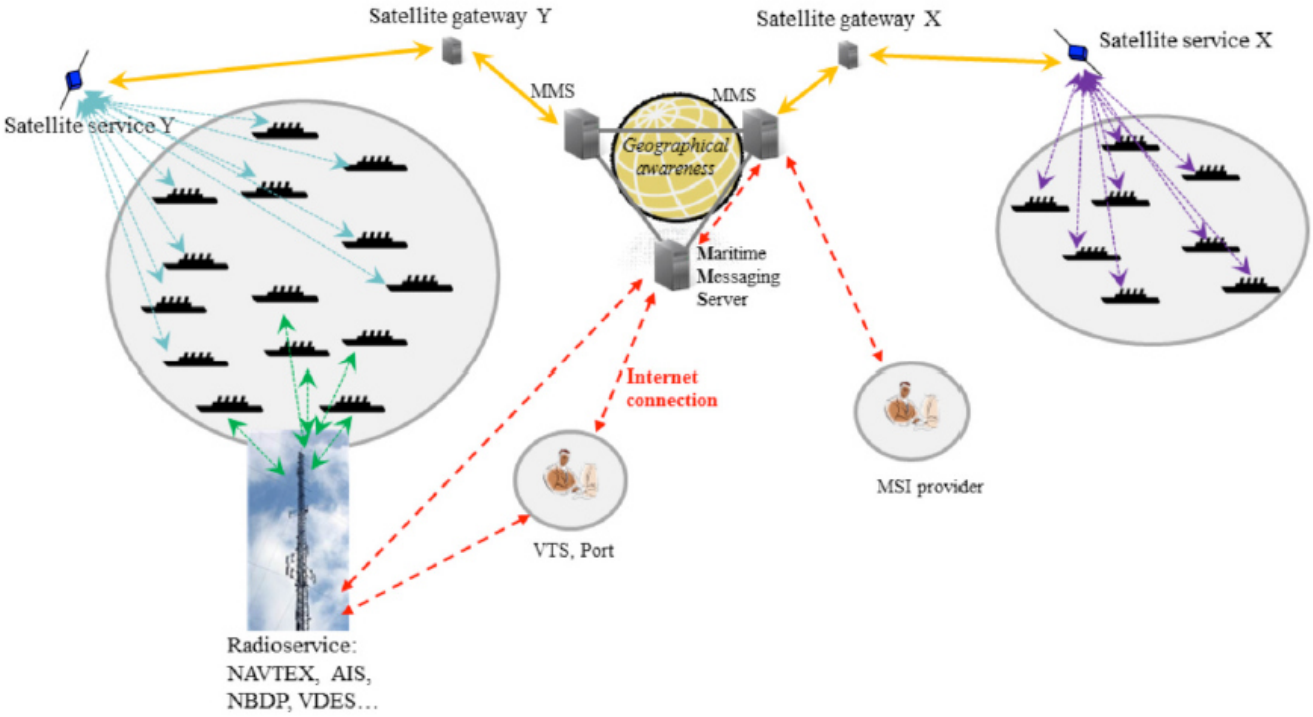

Figure 11. Maritime Cloud communication parameters management (source : EfficienSea 2, task 2.3)

7.3 Seamless roaming operations

The purpose of the seamless roaming is to manage and optimized the hybridization of all the communication systems. The following figure shows the roaming principle and the different interfaces of the Maritime Cloud.

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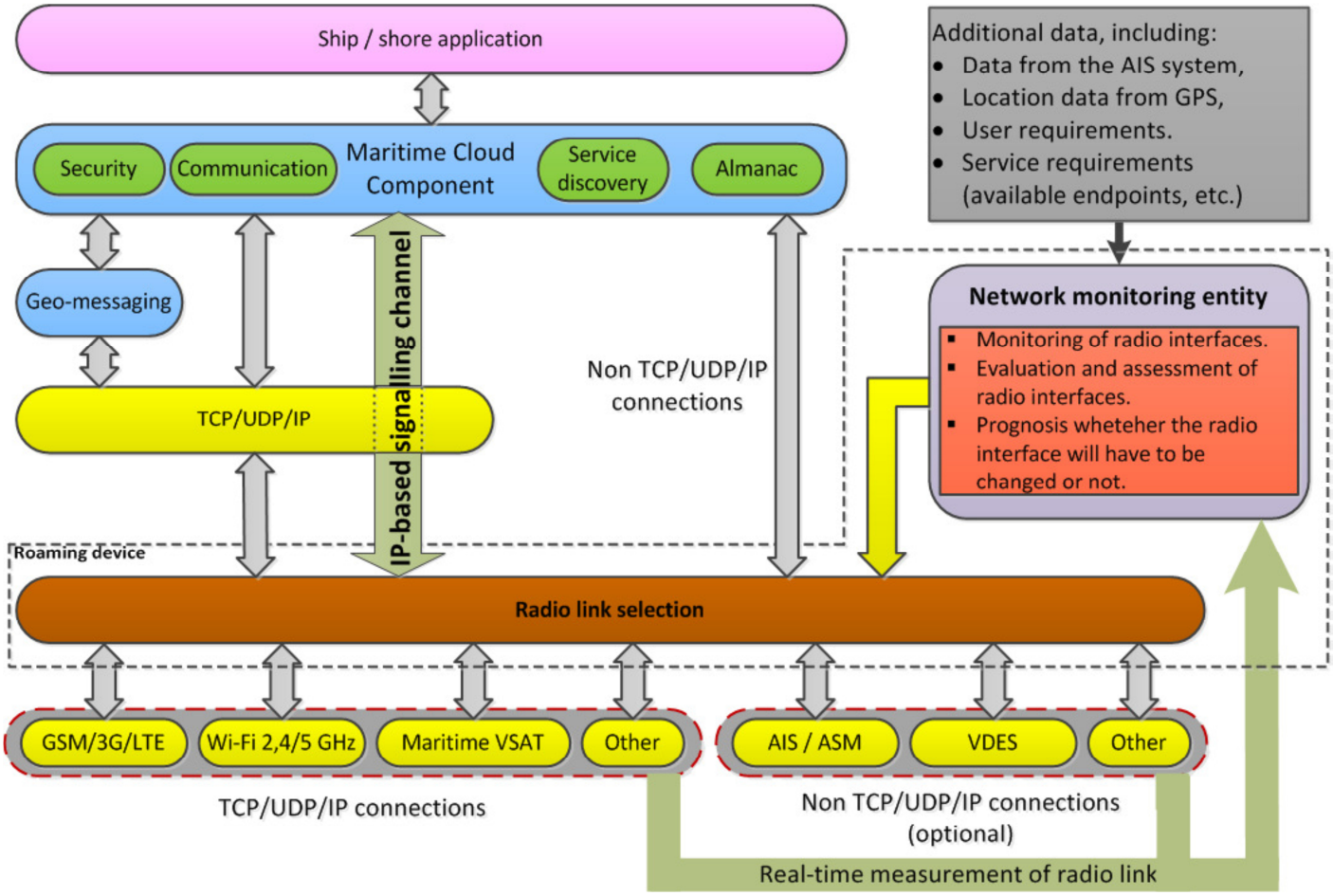

Figure 12. The architecture of the Maritime Cloud client connected with the components of the hybrid communication system and the Seamless Roaming (source : EfficienSea 2, task 2.3)

7.4 EfficienSea 2 services preferences

In the context of EfficienSea 2, the Maritime Cloud and the seamless roaming algorithm will prioritize e-navigation and e-maritime topics. Consequently, the minimization of the transmission duration and/or the minimization of the transmission costs will be preferred among different communication solutions.

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8. Conclusions

This analysis report on available and emerging technologies for the maritime communications shows that the concept of the maritime cloud which is the core of the EfficienSea2 project is completely in line with the IALA maritime radio-communications plan. The maritime domain uses a wide range of communications technologies across the radio spectrum in order to support safe navigation, efficient operations and commercial aspects. Many of these technologies have been developed with a single application in mind. As a result, a vessel needs to carry many different types of communications equipment, in order to be able to receive relevant data. Two main important present communication gaps in the maritime domain that are addressed in the EfficienSea 2 project concern the short range and the polar areas limitations. For short range links, the VHF is the reference communication system with voice and AIS. None of these are intended for transfer of data volumes, why an alternative is needed to facilitate e-navigation related services in these waters. The VDES is a qualified candidate to fill this gap. In November 2015, during the World Radio Conference, the specifications of the terrestrial VDES including the required new VHF frequency bands have been accepted. The system will offer higher VHF transmissions data rate capacity on the shore to ship, ship to shore and ship to ship links. Data rate up 250 kbps will be envisaged (compared to the AIS is at 9.6 kbps). A satellite component of the VDES is also a solution for the extension of the VHF range to broadcast to or collect information from ships for ranges over 100 nm. Compatibility tests between VDE-SAT and VDE-Terr are planned to be implemented in task 2. An important challenge of the EfficienSea 2 project concerns the hybridization of pure maritime communication technologies with terrestrial based systems It may be with cellular networks (3G, 4G, LTE…) and wireless communication technologies like Wi-Fi and wiMAX providing capability for high speed data transfer for general communications. Modern ports and urban water close areas generally provide such terrestrial infrastructure.

The Northern polar latitudes also present a gap in terms of maritime communication. The satellites provide solutions. The VDE-SAT is particularly adapted to broadcast maritime safety information to the ships or to collect messages. However, this system will not be available all the time until a complete LEO satellite constellation is in place. Iridium is the only satellite system that will offer real time communication services in the polar area thanks to its global and permanent LEO constellation coverage. Moreover, the Iridium Next generation should soon be compliant with the GMDSS.

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Annex A: Existing maritime services and satellites communication means

Some maritime communication means are already in place, or will be in place in the near future, it is important to describe what their marketing key points are and what make them viable economically, in order to envisage the VDES future marketing approach

Today's options when considering a global coverage are principally Inmarsat, Iridium and VSAT.

Inmarsat

Founded in 1979, Inmarsat was originally created as an intergovernmental organization to ensure that ships could stay in touch by satellite phone. Today Inmarsat has evolved into a mobile satellite services industry and transformed from an intergovernmental organization to a private company in 1999. In keeping with its government agency beginnings, Inmarsat continues to offer global maritime distress and safety services (GMDSS) to aircrafts and ships at no charge. Today, 185,000 vessels are Inmarsat customers.

Inmarsat faces competition from essentially flat rate, all-you-can-eat packages offered by mobile VSAT solutions. Inmarsat is the maritime market leader, but not currently in fast growing VSAT segment. The launch of the Global Xpress Ku-band and L-band will look to position Inmarsat in the fast growing VSAT segment. It is also facing competition from Iridium's new Force concept which was announced for 2014/ 2015, offering robust global satellite coverage.

The company currently is undertaking acquisitions of service providers like Stratos, Ship Equip and New Wave Broadband. Imarsat's migration toward a more vertically integrated business structure may help bypass indirect sales channels and enable the company to aggressively and directly market services to end-users.

Coverage

Inmarsat operates a fleet of geostationary satellites that cover the earth to around 70 degrees north and south.

To improve satellite coverage, the new Global Xpress satellites will provide global coverage using geostationary satellites, although these satellites do not normally provide coverage at the poles. The extent of coverage will be confirmed nearer the launch of service.

Performance

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In satellite performance, Inmarsat has set a high standard, with end-to-end design specification, quality assurance and a service meeting regulatory needs. Performance is currently evaluated to be at 99% reliable. For the existing Inmarsat satellites, their advantage lies in the fact that there is a clear line of sight to the satellite and there are no obstructions to affect the signal. Inmarsat satellites are always located at points over the equator which means that the closer a ship is to the equator, the higher the satellite and therefore the more precise the signal. Conversely, at the Poles the signal is lower and reduced and therefore certain areas are considered blank spots.

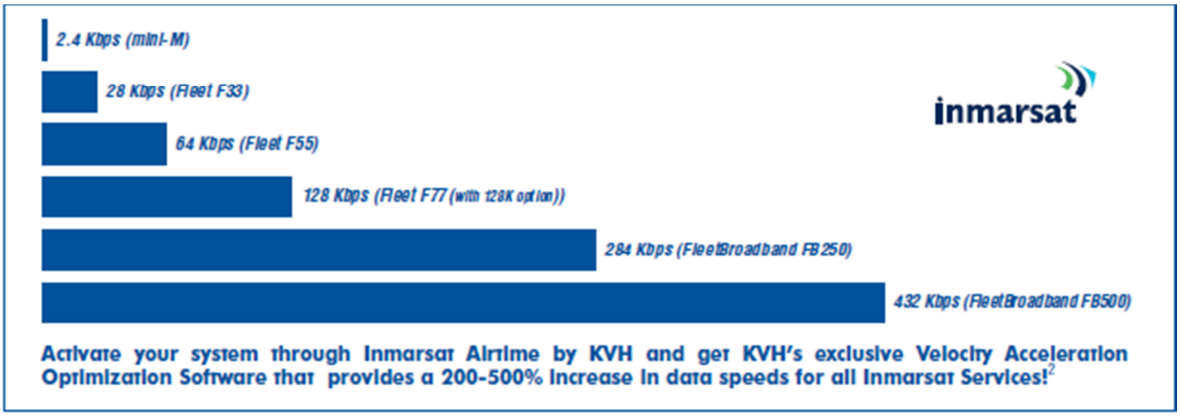
The Global Xpress satellites will operate on Ka-band, which will have rain fade/attenuation issues. L-band shall be used as a backup in order to ensure 100% connection.

Quantity and speed

Inmarsat services have a latency rate of 10 seconds, with a maximum data rate of 600 bps for Inmarsat C, and up to 432 kbps for the Inmarsat Fleetbroadband range.

The new Global Xpress satellites will carry 89 Ka-band beams and operate in geosynchronous orbit using a Ka-band network, which will bring higher speeds. Boeing will build the three new Inmarsat-5 satellites that will offer downlink speeds of up to 50Mbps, and up to 5Mbps over the uplink from compact user terminals as small as 60 centimeters. The company expects to realize $500 million in revenue from the service within five years of launch.

The table below provides a data speed comparison for all current Inmarsat services: -



Source: Inmarsat

Cost

Inmarsat's new pricing structure looks to discomfort those using low data quantities

Their strategy is to penalize those that look to use Inmarsat as a back up to VSAT (fleet, PAYG) and reward those paying for a data bundle via the Fleet Broadband package.

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The proposed prices per service can be found below.

Services

Inmarsat B

Inmarsat B - closed down on 31 December 2014

Inmarsat C:

Inmarsat C is the system that is the most widely implemented, installed on 90-95% of vessels.

Inmarsat-C carries data communications services only. Approved and required for mandatory carriage requirement on SOLAS vessels outside the coverage of NAVTEX (A2) these terminals also provide Distress, Urgency and Safety communications together with the reception of Maritime Safety Information and Enhanced Group Calling (EGC) traffic. Inmarsat-C has SafetyNet and FleetNet services, which transmits important navigational information to maritime users. It is important to note that SafetyNet is part of the GMDSS but that the coverage is not global, indeed polar areas are not covered. Inmarsat C is the only conventional satellite system required by IMO SOLAS Convention, Chapter IV "Radiocommunications". Inmarsat C/mini-C make up more than 148,000 of the 246,000 maritime terminals in service. More than 90000 Maritime Inmarsat C and 58,000 Inmarsat mini-C SESs are in service.

Inmarsat C positioned on the low data transfer segment, operating at 0.6 kilobits and offering minimum data capabilities.

http://www.intelsat.com/wp-content/uploads/2013/05/The_Future_of_Maritime_Satcoms_DSJuneJuly13.pdf

http://www.iho.int/mtg_docs/com_wg/CPRNW/WWNWS4/WWNWS4-3-5-2A.pdf

Inmarsat Fleet

The Inmarsat Fleet services were designed to meet the growing demand for global voice, data, web browsing, and e-mail service. It also provides voice distress and safety services that meet the latest IMO requirements for the Global Maritime Distress and Safety System (GMDSS) (F77 only). An Inmarsat Fleet F77 or F55-compatible antenna provides users at sea with pay-by-the-bit Mobile Packet Data Services (MPDS) and mobile, pay-by-the-minute high-speed ISDN service, as well as voice and fax functions. Inmarsat Fleet F33-compatible antennas offer voice, MPDS and 9.6 Kbps data and fax services.

Price for the services can be found below: -

Type of service	Fleet service	Peak	Super	Quiet

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			Time
Voice per minute	F77, F55, F33	1.89$	1.59$
MPDS per Megabit	F77, F55, F33	3.49 $	
ISDN 1 (64 Kbps) per minute	F77, F55	6.99$	
ISDN 2 (128 Kbps) per minute	F77	12.50$	
Fax (9.6Kbps) per minute	F77, F55, F33	2.79$	
Data (9.6Kbps) per minute	F33	2.79$	

	Peak	Super quiet time
Monday to Friday	6:01 – 19:59	
Saturday and Sunday		24 hours

Source: KVH

Inmarsat have informed sponsors that the availability of Fleet77 terminals may become an issue in the near future. **The Fleet product is being superseded by Inmarsat Fleet Braodband. 30 000 Fleet systems are still commissioned**

http://www.intelsat.com/wp-content/uploads/2013/05/The_Future_of_Maritime_Satcoms_DSJuneJuly13.pdf

FleetBroadband:

FleetBroadband established leader in the market. Maritime portfolio – FB500, FB250, FB150

- Standard IP data (up to 432kbps)
- Voice (accessible simultaneously with data via a single terminal) and fax: 4kbps circuit-switched service
- Streaming IP with guaranteed data rates on-demand
- ISDN for Voice & Data
- SMS via PC & FB handset
- Distress voice on T&T MESs

	Fleetbraodband 500	Fleetbroadband 250	Fleetbroadband 150
Voice	4 kbps	4 kbps	4 kbps

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Standard IP	Up to 432 kbps	Up to 284 kbps	Up to 150kbps
ISDN Data	Yes	No	No
IP Streaming	32, 64, 128, 256 kbps	32, 64, 128,kbps	No

The Fleetbroadband is part of broadband (BGAN) family of services based on 3G network technology and operated over Inmarsat I4 (4th generation) satellites since Nov 2007.

FleetBroadband150 is Inmarsat's entry-level maritime broadband service designed for coastal merchant, small recreational and fishing vessels launched in 2007. The FleetBroadband 150 service enables smaller vessels to benefit from simultaneous voice, SMS at data and IP data, rates of up to 150kbps.

FleetBroadband250

Like the 150, this product has also been developed with lower specification and smaller dome dimension. It is designed for coastal freighters, yachts >40'/21m, fishing vessels, tugs, work boats, coast guard vessels and patrol vessels. The FleetBroadband 150 service enables smaller vessels to benefit from simultaneous voice, SMS at data and IP data, rates of up to 284kbps.

Fleetbroadband500

This is the highest specified product in the series and will typically target customers with demanding data requirements. This offer addresses the following group of customers: Commercial vessels (Cargo, Tanker, Bulk carriers, Ferries, Cruise liners, Offshore supply vessels), Yachts >70'/21m, Defence crafts, System Integrators and Application Providers.

FleetBroadband system is not GMDSS compliant however there are safety services offered.

Maritime Safety Voice Services (MSVS)

This service looks to provide distress and urgency voice communications via an Emergency Calling service.
Free voice calls facility (standard with FleetBroadband)

- Dial '505' mariners to reach a Maritime Rescue Co-ordination Centre (MRCC)
- In a voice distress call, the FleetBroadband system provides
    - Call number Identification (CNI)
    - E-mail generated with terminal identification details, ship's name, IMO number, call sign, the position and other information
    - This information is distributed to the relevant RCC, the Network Operations Centre and the Satellite Access Station

Note: 505 Emergency Calling is not compliant with the Global Maritime Distress and Safety System (GMDSS). If the vessel is larger than 300GRT, it should be carrying equipment that is compliant with GMDSS. This equipment should be used in the first instance to contact a Maritime Rescue Coordination Centre (MRCC)

Maritime Data Safety Services (MSDS).

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Like the Inmarsat C SafetyNET service, MSDS will be used to distribute maritime safety information and warnings such as navigational and weather warnings. These could include having a graphical element such as a meteorological chart sent with a weather alert. Additionally, the service could include new safety offering such as live chat rooms. Using the new technology of the Inmarsat-4 satellites and the BGAN network, it can introduce additional services and good satellite reliability.

- Central Server with remote back up
    - Distress Alerting and messaging – Ship/Shore
    - Urgency priority messaging (32/38/39)
    - Safety priority messaging (41/42/43)
    - Promulgation of MSI (D/U/S)
    - Distress priority "Chat"
    - Subscription services, such as:
        - Out of area navigation and weather warnings
        - Graphical weather information
        - Chart updates
        - Notice to mariners
        - eNav requirements

here below are some of the applications that have been highlighted in more detail by Inmarsat:-

- **Alerts**

MSDS will enable greater availability of information, with mariners able to check alerts for regions they are heading towards in advance or any broadcasts they may have missed if, in dry dock, for example. Distress alerting will work the same as on Inmarsat C, with the press of a button sending an auto alert to an MRCC, but with the additional capability of enhanced information being provided. Voice distress calling will also be available.

- **Chat Room**

A ship in trouble will be able to communicate with all those coming to its assistance through the data services. The MRCC will be able to set up data incident chat rooms and invite other rescue co-ordination centers and vessels in the area to join. This will overcome some of the language barrier problems experienced with emergency voice calls.

- **Satellite piracy solutions**

To complement the SSAS service, Inmarsat's voice distress service '505' emergency service for the industry utilises FleetBroadband to provide priority call access, interrupting all non-distress calls – either ship-to-shore or shore-to-ship – as soon as the 'red distress button' on the alarm panel is pressed. The caller will then be connected to an operator at one of three Maritime Rescue Co-ordination Centres (MRCCs).

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Global Xpress

Inmarsat partnered with iDirect in February 18, 2010 to develop ground network infrastructure for the Inmarsat Global Xpress services. Inmarsat's Ka-band broadband network, planned to launch in 2014, will offer downlink speeds of up to 50Mbps through a small compact terminal. XpressLink will act as a bridge to Inmarsat's Global Xpress service through a free terminal upgrade. XpressLink is a fully-integrated Ku-band and L-band solution delivering high-speed broadband at a fixed monthly fee.

GMDSS Communication Functions via Satellite

There are presently three recognized Inmarsat communications systems through which a SOLAS vessel can comply with part of the GMDSS Sea Area A3 requirements. All use the Inmarsat 3 constellation and all provide MSI. A summary of functions can be found below.

GMDSS Functions	INM- B	Inm-F77	Inm-C
Distress alerting ship to shore	Yes (voice)	Yes (voice)	Yes
Distress alerting shore to ship		Yes (voice)	Yes
Distress alerting ship to ship			
SAR communications	Yes	Yes	Yes
On scene communications			
Tx/Rx of MSI	Yes (txt)	Yes (txt)	Yes
Locating signals			
General communications	Yes	Yes	Yes
Bridge to bridge communications			

Inmarsat's objectives

- Obtaining IMO approval for Voice and Data Distress and Safety Services on I4
- Introducing innovation in maritime communications
- Playing an active part in GMDSS modernisation
- Enabling integration and exporting of MSI data to navigational systems

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http://www.thedigitalship.com/powerpoints/sing12/day1/DS_Singapore2012_Peter_Blackhurst_Inmarsat.pdf

Iridium

Iridium is a growing rival to INMARSAT, particularly with its new Iridium Force concept coming on line by 2014 and in 2015 The Iridium constellation is comprised of 66 Low Earth Orbit (LEO) satellites with additional in orbit spares. 6 orbiting spares and 9 spares on the ground as part of a hybrid insurance strategy bring the total to 81 satellites.

Coverage

Its system of LEO L band Satellites provides global coverage, including the Polar Regions.

In addition, the Iridium NEXT satellites which will be started to be launched in 2015, will be capable of providing polar region coverage — a key advantage the company hopes to exploit, as sea routes once closed off by ice open up to traffic. The low-Earth orbit allows for portable phones or fixed installations with very small external antennas and superior voice connections.

Performance

This unique network architecture of meshed, cross-linked satellites provides inherent advantages in performance and reliability.

Speed, latency

Iridium Force concept coming on line by 2014 and 2015, the Iridium NEXT system with speeds of up to 1.5Mbps.

Costs

Iridium Next, the new satellite network, planned to be launched by 2015 and is expected to have lower costs than today without having to change on-board equipments.

Services

- SBD

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Iridium SBD network is a transport capability for transmitting short data messages between equipment and centralized host computer systems.

- SMS

Iridium SMS provides a two-way messaging service, allowing Iridium users to send, receive, and respond to messages that are stored for up to seven days on the network and automatically delivered when phones are powered on.

- RUDICS

The Iridium Router-Based Unrestricted Digital Internetworking Connectivity Solutions (RUDICS) is an enhanced data service that allows customers who have requirements for large data transfers the ability to transfer data via multi-protocol Mobile Originated (MO) and Mobile Terminated (MT) circuit switched data connectivity across the Iridium satellite network. It allows customers to send and receive data traffic over the Iridium network using an optimized circuit switched data channel. It utilizes circuit switching technology via a dial-up modem and ISDN for low-bandwidth data transfer for ISUs, enabling a host application to originate and terminate numerous connections simultaneously. This solution utilizes Network Access Servers to provide modem ports, supporting both Mobile-Originated (MO) and Mobile-Terminated (MT) Circuit Switch Data calls.

- Iridium Openport/ Pilot broadband

Iridium OpenPort is no longer available for purchase and has been replaced by its second generation maritime solution, Iridium Pilot.

<u>Iridium Pilot Features</u>

- Three separate phone lines, that can be used simultaneously
  Internet Connectivity (up to 134 Kbps)
  Flexible pricing packages
  Lightweight, low-profile
  5 Year limited warranty
- 100% global... Even on the North and South poles
  Built for Extreme conditions - Heat, cold, wind, rain, rolling seas

These capabilities include a built-in firewall for traffic management and a bulk configuration capability to assist in managing large volumes of units.

- Iridium Next

The Iridium next project looks to fully replace the current Iridium constellation and updates the ground system with new features and capabilities. Significant advantages of the project include expanded capacity, higher data speeds and ability to host payloads

•Deployment approach designed to provide service continuity
• Cross-linked architecture

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• 66 low-Earth orbit satellites
• 6 in-orbit spares, 9 spares on the ground
• 3 million subscriber capacity
• L-band data speeds of up to 1.5 Mbps
• High-speed Ka-Band service of up to 8 Mbps
• Global coverage
• Enhanced voice quality
• High reliability and low-latency
• Flexible allocation of bandwidth
• Private network gateways
• Backward compatibility with current handsets and devices
• Software upgradable – capable of supporting future product enhancements
• Efficient integration of applications
• Advantages of IP Technology
• Designed to host secondary payloads

Importantly, Iridium Pilot will be compatible with Iridium's next generation satellite constellation, Iridium NEXT. This means that ship operators installing Iridium Pilot can be confident that their equipment will be supported well beyond 2020.

http://investor.iridium.com/releasedetail.cfm?ReleaseID=647496

VSAT

V-SAT is an on board equipment generally present in cargo vessels. This communication means allow to receive navigation and safety-related information. It is important to note that the coverage is not global and that it is currently not mandatory on-board vessels. Therefore, not all the vessels are equipped of V-SAT. A switch box can allow the mariner to change is way of communicating if he is in an area not covered by V-SAT.

Demand for VSAT services in the commercial maritime sector has increased significantly in the last 5 years. Much of this demand is driven by ship operators seeking operational efficiency and improved business processes through the implementation of enterprise software applications. However, the rate of adoption of VSAT technology is being limited by coverage, cost and the inability of the industry to identify the true value of VSAT for ship operators. Furthermore, VSAT lacks a governing authority; there are multiple manufacturers and no end-to-end QA standards.

Coverage of VSAT
Regional coverage (limited global coverage) provided by multiple satellite service providers (seamless roaming possible without any roaming surcharge).

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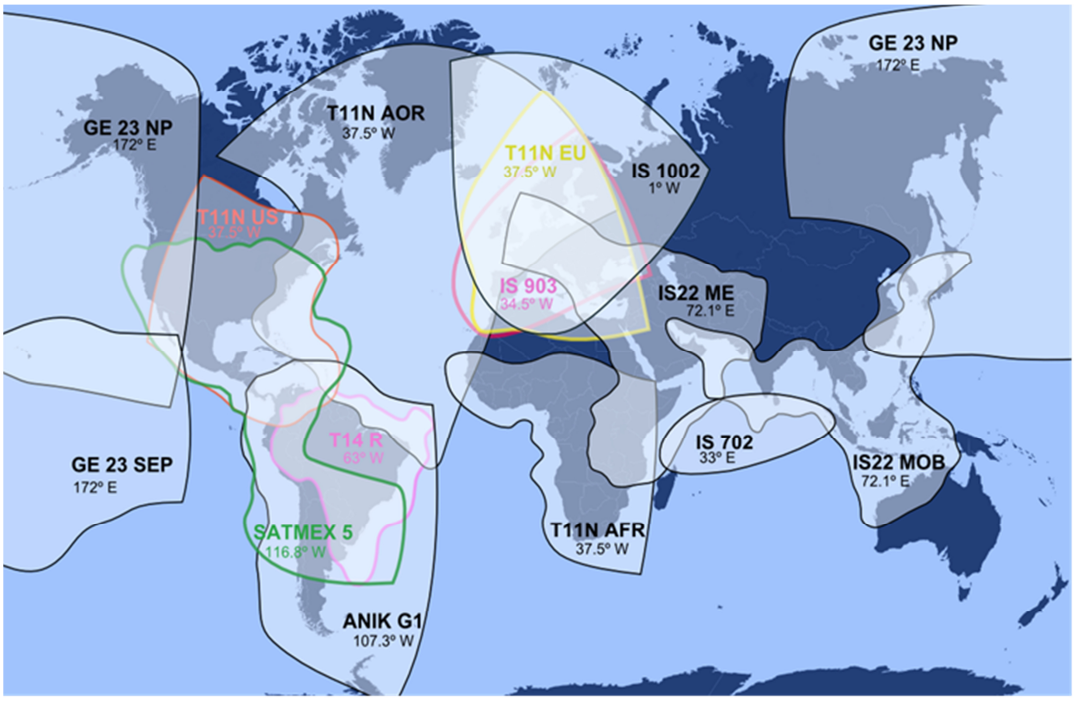

Quantity and speed

Here below is a table resuming the data transfer rate

Download	Upload	VOIP included
512 kbps	128kbps	1
1024 kbps	256 kbps	1 or 2 lines
2048kbps	512 kbps	2 or 4 lines
4096kbps	1024kbps	4 lines
6120kbps	1536kbps	4 lines

Source http://www.maritime-systems.net/mns/VSAT.html

Cost

Maritime VSAT can be supplied on a standard IP or guaranteed data rate basis. VSAT is supplied at a high cost – installing the antenna costs up to 10 times that of its rivals– and the subscription is usually at a minimum of a 12 months. Compared with Fleetbroadband, the breakeven point is in the

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region of 2GB per month. VSAT alternatives in a host of configurations and price ranges have proliferated. Some VSAT suppliers give the option of renting VSAT equipment, where installation is free.

It is important to note that a certain amount of space is required for VSAT antenna. A Ku-band antenna is about 1m in diameter and typically sits inside a 1.2m-diameter dome, whereas a C-band antenna is larger and needs a 3.4m-diameter dome. Both need to be sited as high as possible on a vessel in such a way that there are no 'line of sight' issues."
For this reason, it is understood that smaller vessels are choosing either FleetBroadband or Inmarsat's existing services such as Inmarsat C.

http://www.stratosglobal.com/~/media/Documents/Corp/Public/corp/corp_publication/corp_publication_safetyAtSea09Feb.pdf

Russian PolarStar

Gazprom Space Systems is developing the prospective space mobile broadband access system named PolarStar. One of the main tasks of the PolarStar system is the provision of mobile and remote objects of Gazprom with communications, including the objects located in arctic region. The basis of the system is the orbital group of HEO satellites. The first satellite over 3 planned YAMAL-300K has been launched successfully on Nov. 2012.

Coverage

Total territory of Russia and Polar Regions

Size and speed

The satellite will be equipped with Ka bandwidth with up to 10.0/2.0 Mbps for multiple access and pp to 1.0/0.25 Mbps in individual access. The systems maximum capacity rate is 1.5 – 2.0 Gbps

Service

Broadband access (high speed Internet access, e-mail, telephony, TV and radio reception) for mobile and fixed objects.

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Canadian Polar Communication and Weather mission

This satellite mission looks to improve satellite coverage over areas of the Canadian territory that cannot be covered by GEO satellites and as well as the High Arctic, particularly for mobile services used by ships, planes and Unmanned Aerial Vehicles (UAVs). It will also be used for meteorological observation coverage in the Arctic. 2 HOE satellites are planned to be launched in 2016 with operations in 2017.

Coverage

The PCW (Polar Communication and Weather) satellites will give 24/7 hour (continuous) coverage over the Arctic and the North Canada. The project looks to become operational in 2017 although funding for the project is still underway.

In addition, the scientific instrument package, called Polar Highly Elliptical Molniya Orbital Science for PWC, will provide essential Arctic weather, climate and air quality data from the PWC satellite.

Services

- 24/7 Broadband communications services everywhere in the AOI
- GNSS augmentation (TBC)
- ATM communications (TBC)
- Winds from sequences of images: high priority product
- Surface type analysis: ice, snow, ocean, vegetation and surface characteristics such as emissivity, albedo, vegetation index
- Surface temperature, detection of boundary-layer temperature inversions, diurnal cycle
- Mid-tropospheric humidity/temperature sensitive channels for hourly direct assimilation complementing GEO radiance assimilation
- Volcanic ash detection
- Smoke, dust, aerosols, fog in support of air quality models and environmental prediction
- Total column ozone
- Cloud parameters: height, fraction, temperature, emissivity, phase, effective particle size
- Broadband outgoing radiation: total, Vis, IR, window

Overview

- 2 satellites in 2 orbital plains to provide continuous GEO-like imagery 50-90 N
- Ka-, and X-band
- 20 VIS & IR bands
- 0.5-1 km VIS
- 2 km IR
- 12-h period
- 63.4 deg. inclination
- Apogee: ~39,500 km
- Perigee: ~600 km

http://bprc.osu.edu/rsl/GIIPSY/documents/P7%20-%20PCW_Space%20and%20Arctic.pdf

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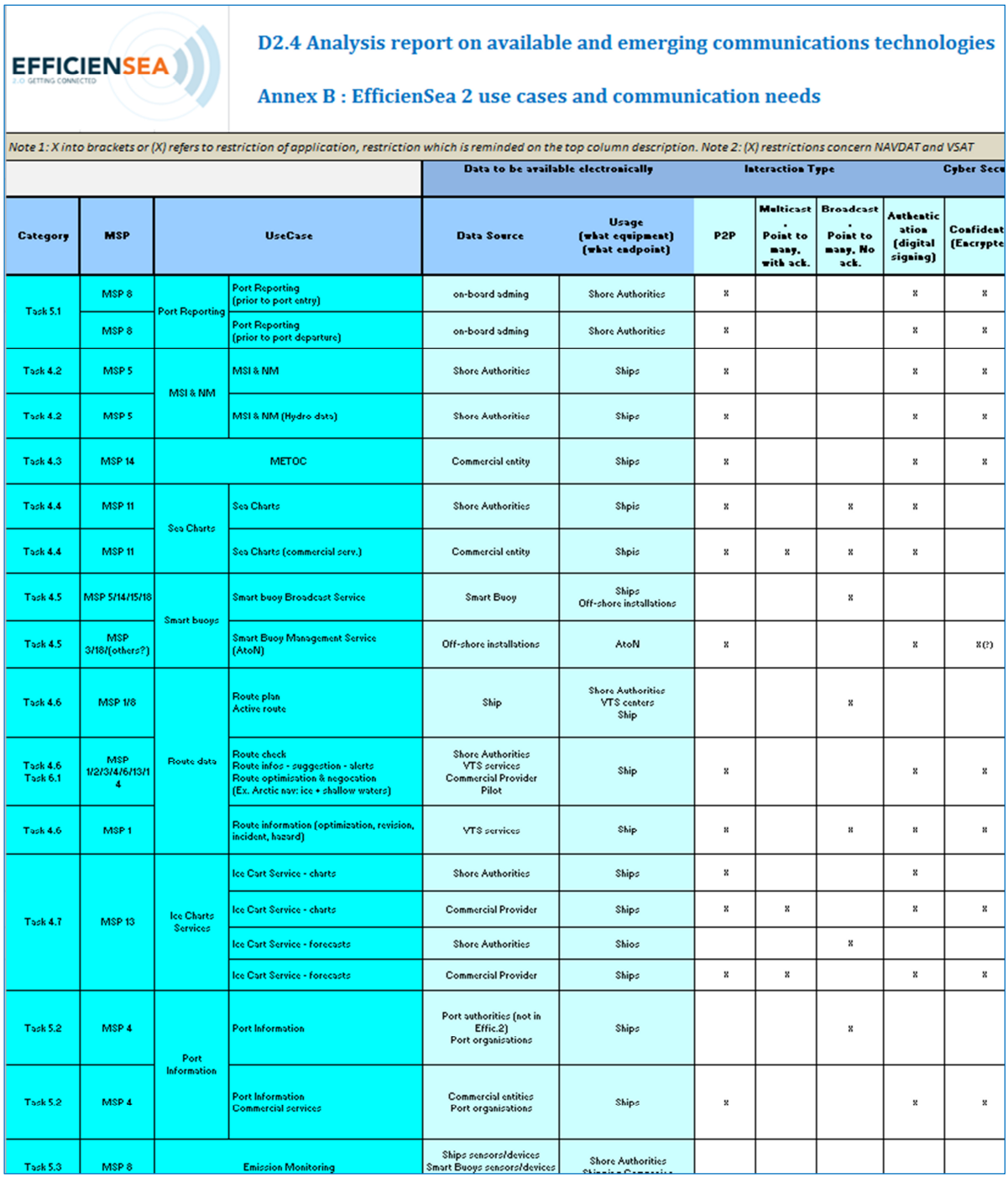
Annex B : EfficienSea 2 use cases and communication needs

See the separate excel sheet titled '*Service Communication Requirements WP3-WP2 - CLS_v1'*

Figure Annex B1. Frontpage of the spreadsheet



EFFICIENSEA 2.0 GETTING CONNECTED

D2.4 Analysis report on available and emerging communications technologies

Annex B : EfficienSea 2 use cases and communication needs

Note 1: X into brackets or (X) refers to restriction of application, restriction which is reminded on the top column description. Note 2: (X) restrictions concern NAVDAT and VSAT

				Data to be available electronically		Interaction Type				Cyber Secu
Category	**MSP**	**UseCase**		**Data Source**	**Usage (what equipment) (what endpoint)**	**P2P**	**Multicast - Point to many, with ack.**	**Broadcast - Point to many, No ack.**	**Authentication (digital signing)**	**Confident (Encrypte**
Task 5.1	MSP 8	Port Reporting	Port Reporting (prior to port entry)	on-board admng	Shore Authorities	x			x	x
	MSP 8		Port Reporting (prior to port departure)	on-board admng	Shore Authorities	x			x	x
Task 4.2	MSP 5	MSI & NM	MSI & NM	Shore Authorities	Ships	x			x	x
Task 4.2	MSP 5		MSI & NM (Hydro data)	Shore Authorities	Ships	x			x	x
Task 4.3	MSP 14	METOC		Commercial entity	Ships	x			x	x
Task 4.4	MSP 11	Sea Charts	Sea Charts	Shore Authorities	Shpis	x		x	x	
Task 4.4	MSP 11		Sea Charts (commercial serv.)	Commercial entity	Shpis	x	x	x	x	
Task 4.5	MSP 5/14/15/18	Smart buoys	Smart buoy Broadcast Service	Smart Buoy	Ships Off-shore installations			x		
Task 4.5	MSP 3/18/(others?)		Smart Buoy Management Service (AtoN)	Off-shore installations	AtoN	x			x	x(?)
Task 4.6	MSP 1/8	Route data	Route plan Active route	Ship	Shore Authorities VTS centers Ship			x		
Task 4.6 Task 6.1	MSP 1/2/3/4/6/13/14		Route check Route infos - suggestion - alerts Route optimisation & negociation (Ex. Arctic nav: ice + shallow waters)	Shore Authorities VTS services Commercial Provider Pilot	Ship	x			x	x
Task 4.6	MSP 1		Route information (optimization, revision, incident, hazard)	VTS services	Ship	x		x	x	x
Task 4.7	MSP 13	Ice Charts Services	Ice Cart Service - charts	Shore Authorities	Ships	x			x	
			Ice Cart Service - charts	Commercial Provider	Ships	x	x		x	x
			Ice Cart Service - forecasts	Shore Authorities	Shios			x		
			Ice Cart Service - forecasts	Commercial Provider	Ships	x	x		x	x
Task 5.2	MSP 4	Port Information	Port Information	Port authorities (not in Effic.2) Port organisations	Ships			x		
Task 5.2	MSP 4		Port Information Commercial services	Commercial entities Port organisations	Ships	x			x	x
Task 5.3	MSP 8	Emission Monitoring		Ships sensors/devices Smart Buoys sensors/devices	Shore Authorities					

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